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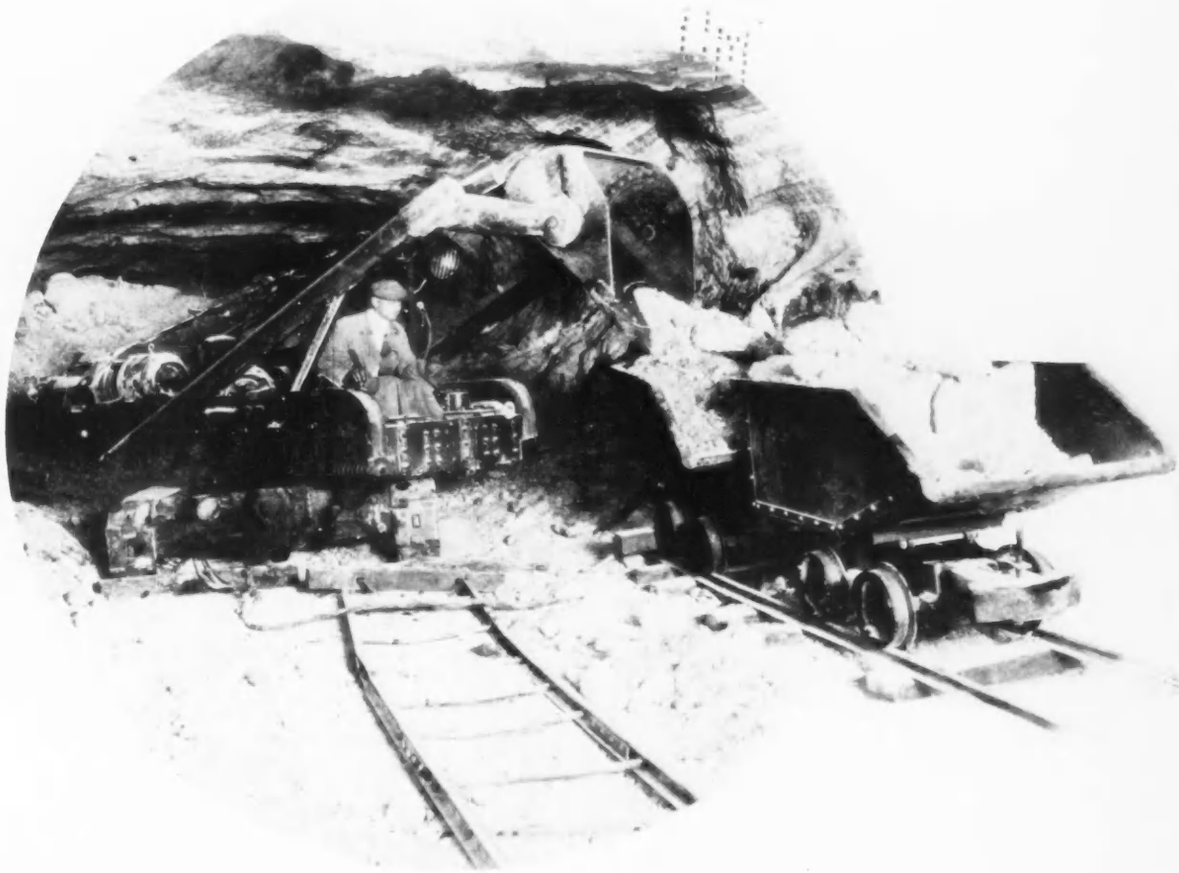

Electric shovels are giving miners the joy of easy gang work instead of sour, brooding isolation. In one coal mine they are playing a part in a mechanization program that is reducing cost per ton twenty-five per cent. Thus, the work of the product engineer is affecting our whole social structure

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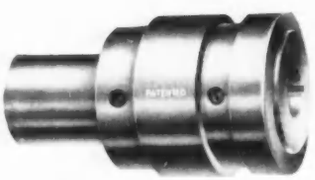
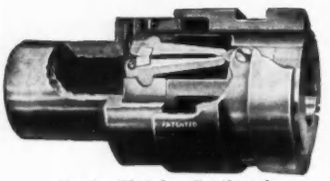
VARIOUS VIEWS OF THE SUPER-JOHNSON CLUTCH



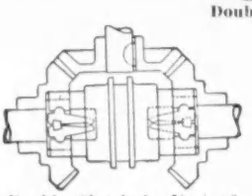
Single Clutch—Exterior



Single Clutch—Sectioned

Double Clutch—Exterior

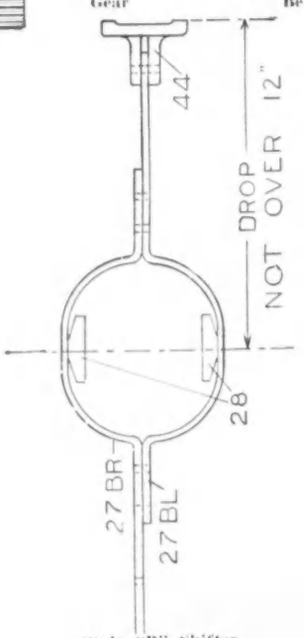
Single Clutch With Spur Gear



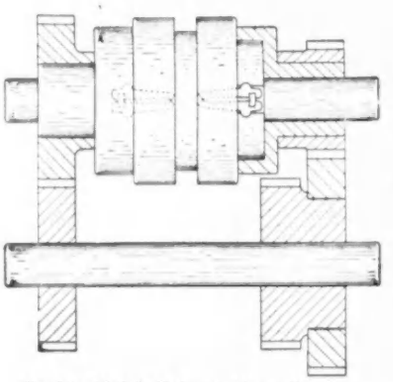
Double Clutch in Nest of Bevel Gearing

Double Clutch with Pulleys

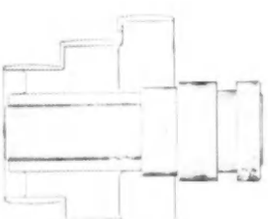
Single Clutch with Pulley



Style "B" Shifter

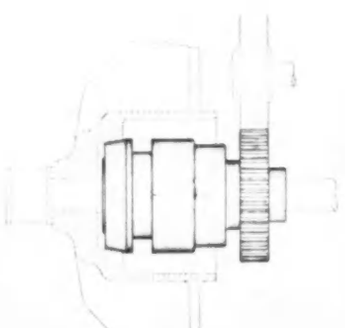


Double Clutch Between Spur Gearing

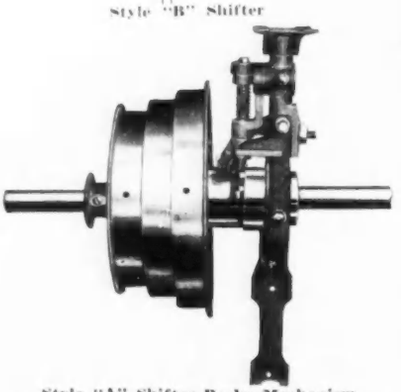


Single Clutch with Cone Pulley on Hub

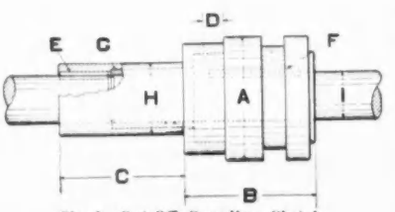
Double Clutch Between Bevel Gearing



Single Clutch With Braking Feature and Spur Gear



Style "A" Shifter Brake Mechanism Stops the Machine Instantly When Clutch Is Disengaged.



Single Cut-Off Coupling Clutch

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Contents for January, 1931

VOLUME 2 . . . NUMBER 1

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McGRAW-HILL PUBLISHING COMPANY, INC., TENTH AVE. AT 36th ST., NEW YORK, N. Y.

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CABLE ADDRESS:
"MACHINIST, N. Y."

Published monthly. $2 per year, 25 cents per copy. Entered as second-class matter, January 17, 1930, at the Post Office at New York, N. Y., under the Act of March 3, 1879.

Number of copies printed this issue, 10,000
Number of paid subscribers, Dec. 10, 1930—7,373

NEW YORK District Office, 285 Madison Ave.
BOSTON, 1427 Statler Building
WASHINGTON, National Press Building
CHICAGO, 520 North Michigan Avenue
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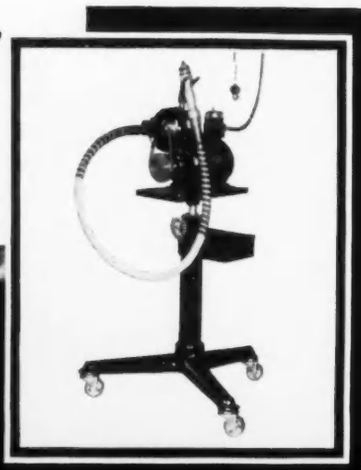

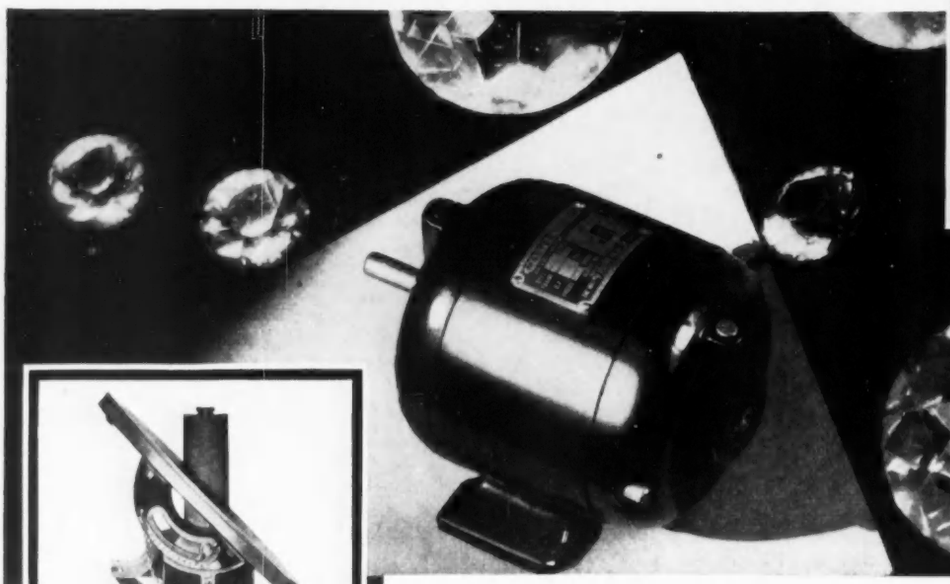

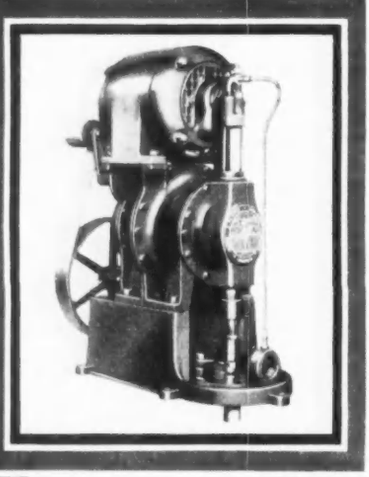

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PRODUCT ENGINEERING

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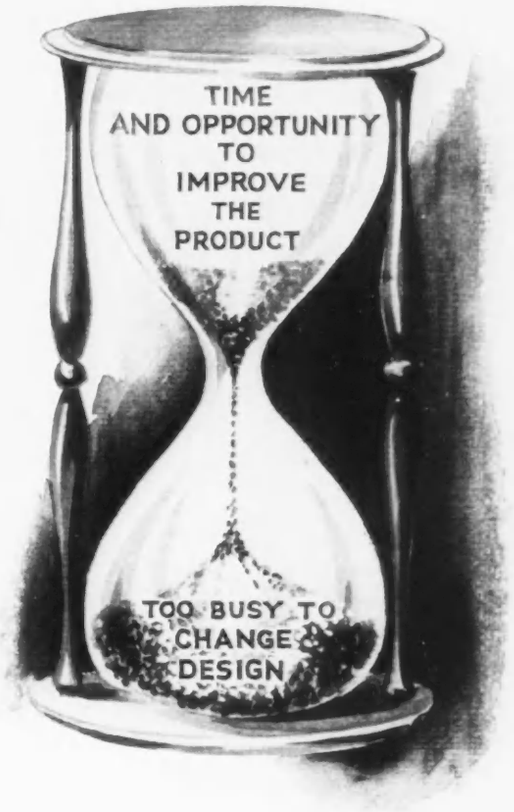
January, 1931

THE TIME GROWS SHORT



BUSINESS DEPRESSIONS are terrible things. They are to blame for the one great failing of our present industrial system—periodic unemployment for those who want to work, and who must earn money to support dependents.

Yet, like wars, they have at least a few mitigating features. One of these is the general elimination of dead wood in the shape of needless routine, obsolete practices, slow-moving products. When income is large, and production and sales activities demand all the energies of executives, the wasteful items do not get the attention they should.

Particularly is this true of designs that have fallen from public favor. Executive interest is directed elsewhere, and the product engineer lacks either the authority or the initiative to force concentration on the product and its design.

But when the business tide recedes the product engineer has his opportunity. The sales department demands a new design, or a re-design that will catch the public fancy. The manufacturing department pleads for something to make.

For a year, now, just such conditions have been current. And certain product engineers have taken advantage of them and have developed products sufficiently in advance of familiar ones to attract the buyer and create business in spite of general dullness.

Unquestionably, we are nearing the end of depression and approaching the period of revival. When we get well into that period it is inevitable that the attention of executives will swing back to production and distribution details. And then the product engineer who has not proved the importance of his function by his accomplishments during this year will slip back to relative obscurity, and will have the old struggle for attention to begin all over again.

But there is still time. Business always climbs up the next peak of prosperity more slowly than it coasted off the last one. Many a product can still be improved in soundness of technical design, excellence of performance, and attractiveness of appearance before the rush of buying makes it possible to market products of lesser merit, and thus increases competition. Product engineers who have made progress can consolidate their positions, and those who have yet to get going can make a start. But start they must, because so many improvements and innovations are on the way in almost every field that the company which pins its faith to the design of last year will find that faith misplaced.

Maximum Capacity with Minimum Dimensions

By EMERY J. WILSON
Consulting Engineer, Thew Shovel Company

An electric mining shovel for operation in restricted space without sacrificing capacity and working range

POWER shovels for loading cars in mines must of necessity have many features not required of similar materials-handling equipment designed for operation in the open. Unusual compactness is one of the outstanding requirements. Low mine drifts limit the permissible vertical height for operating the shovel. Often, in moving from one place of operation to another, the machine must travel through passages having extremely low head room. This condition must also be provided for in the design of the machine. Closely spaced mine pillars limit horizontal dimensions and working clearances, and require the machine to have great maneuverability.

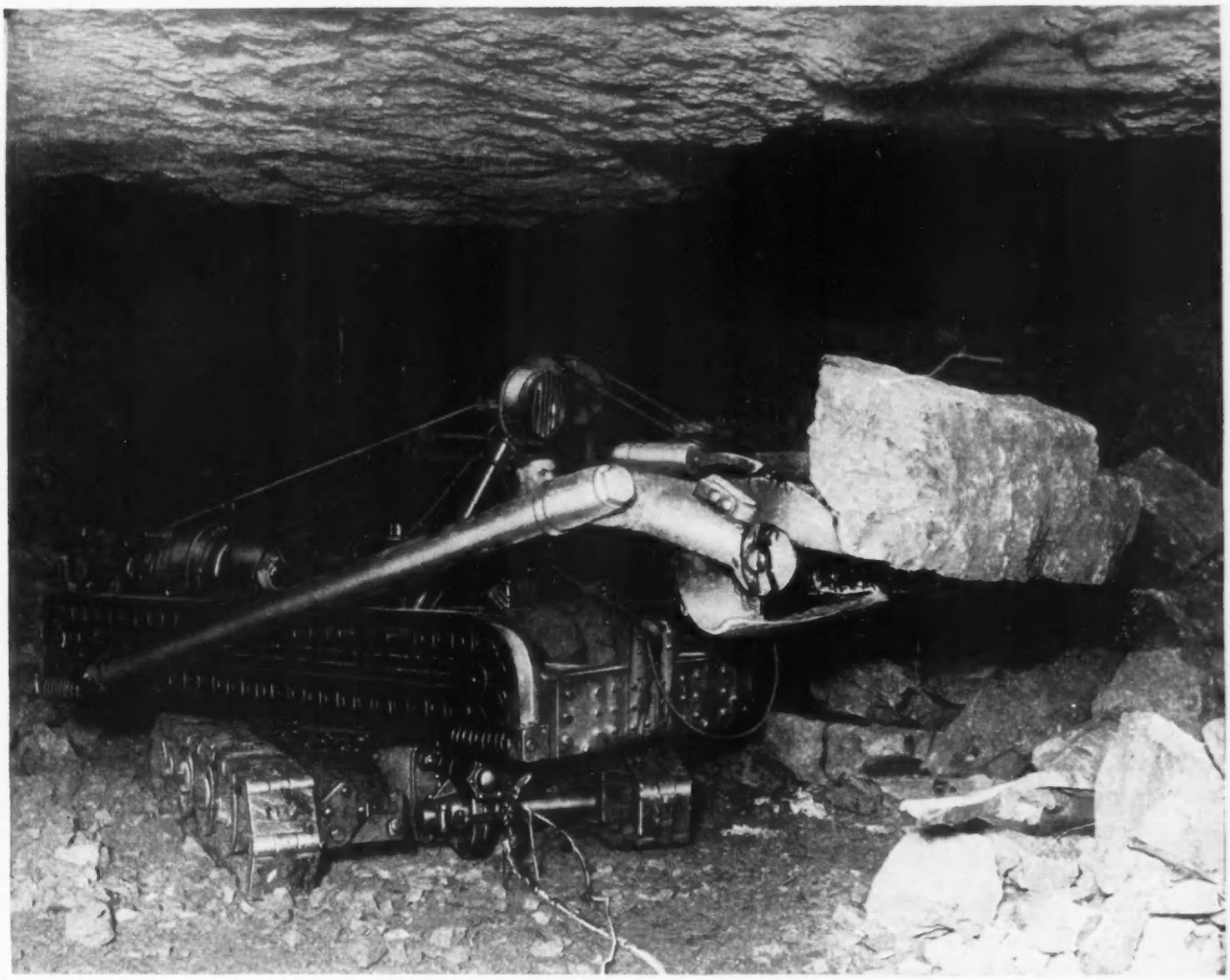
As is common to equipment of this character, mine shovels must be strong and durable and involve a minimum number of adjustments. Yet these machines must be light enough to be transported readily between distant locations. Also, the control must be such that the shovel may be operated with the greatest rapidity, as the unit of tonnage that can be handled by such a machine is necessarily restricted by its limited dimensions. With it all, automatic features must be incorporated for safety and to prevent breakage from careless operation.

Mine shovels must be capable of cleaning up relatively small piles of ore from the floor of the mine. For this reason, and because of the fact that the machine is required to operate in restricted spaces, the open-top scoop type of dipper mounted for horizontal digging was adopted in the design of the Thew type S mine shovel described in this article. The dipper moves into the ore pile horizontally, simulating in all of its movements the action of a man shoveling.

The accompanying drawings and illustrations show the general construction of the machine. The dipper is trunnioned on a cast nickel-steel cross member, which in turn is fastened rigidly to the ends of two parallel tubular legs of the boom structure made of 6-in. steel pipe. Each leg is pivoted at its other end to a crosshead mounted in a horizontal guide on either side of the rotatable superstructure. Each crosshead is attached to a link chain, called a crowd chain. The chains pull the crossheads. In this way the dipper is crowded into the ore pile, or retracted. The maximum stroke is 7 ft. A turnbuckle is inserted in each crowd chain for adjusting the chain tension. Both crowd chains have their driving sprocket keyed on to the same shaft, on which is also mounted a fusee drum.

Horizontal travel at the lip of the dipper is necessary. It is obtained automatically by the fusee drum, one end of the boom hoisting cable being fastened to this drum. As the fusee drum is keyed to the chain sprocket drive shaft, its rotation is at all times in synchronism with the horizontal movement of the dipper. The conical, spirally grooved fusee drum is designed so that the amount of cable wound or unwound exactly compensates for the length of cable required to maintain horizontal travel of the boom and dipper. Loosely mounted on the same shaft with the fusee drum, but driven by an independent motor, is the hoisting drum for raising and lowering the boom. The hoisting cable is rigged as shown in the drawing, one end winding on the fusee drum, and the other end on the hoisting drum.

Instead of separate teeth, the lip of the dipper is provided with a single high-manganese steel casting, the working edge of which is serrated.



SMALL BUT POWERFUL, these shovels can operate in confined spaces, handling two-ton loads with great rapidity

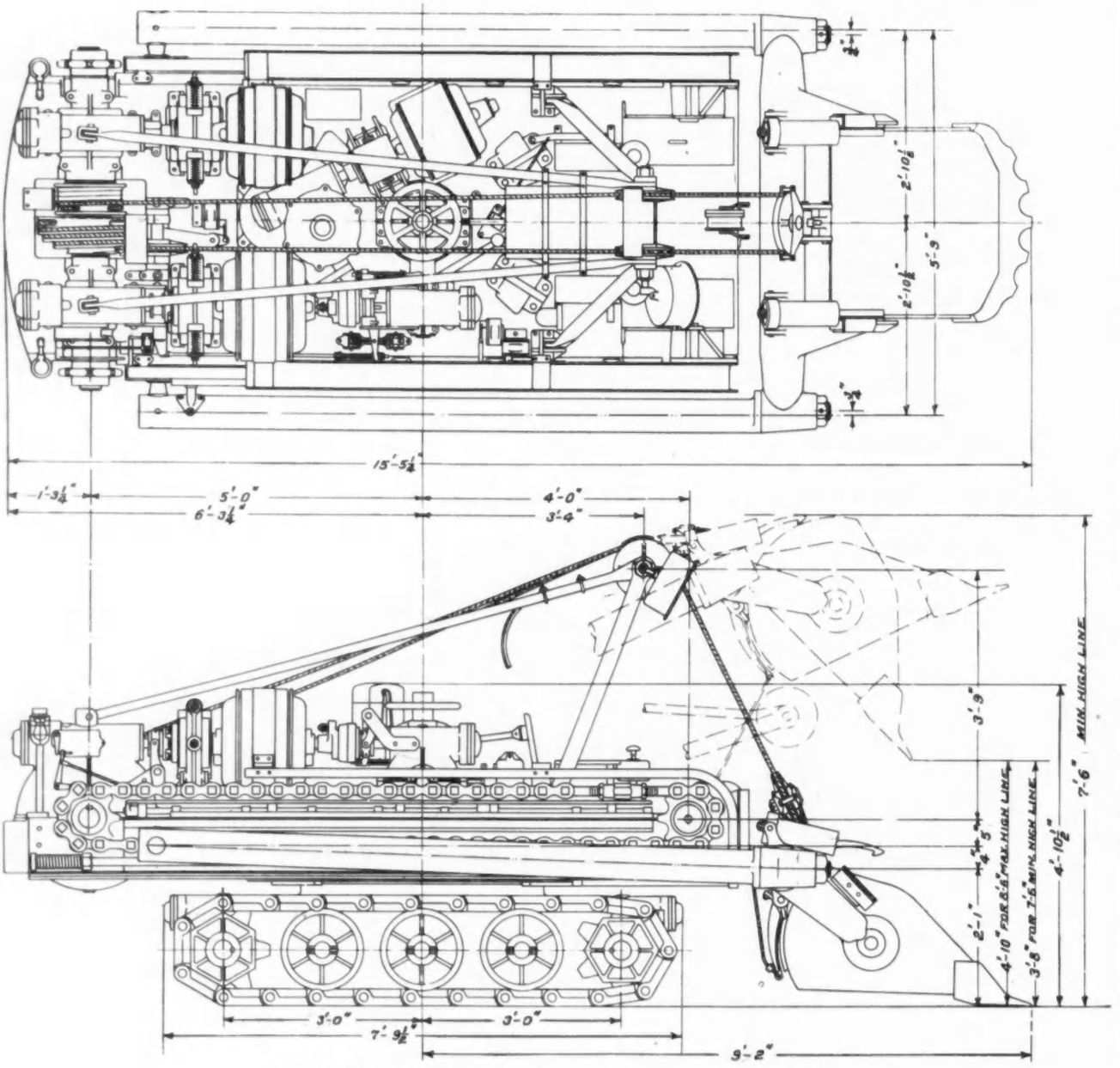
This type of lip has been found exceptionally satisfactory for handling ores. A bronze bushing for the pivoting trunnions, is riveted on each side of the steel plate dipper. The trunnions are a press fit in the boom end-tie casting. A latch holds the dipper in position.

Automatic dumping and a quick return to the latched position is essential for rapid manipulation. Therefore, the pivoting axis of the scoop was very carefully located with respect to the centers of gravity of the empty and loaded dipper so that upon release of the latch the dipper dumps and returns to the latched position. As shown in the elevation, when the dipper approaches its extreme discharging position, a plate on the back of the scoop engages a pair of latches, each of which is directly connected to a spring bumper. Thus, there is no shock when the dipper is dumped. After discharging its load, the dipper returns automatically to its digging position. Release of the latch for discharging the dipper is accomplished by pressing a pedal, located convenient to the operator's foot, thereby braking the rotation of a retrieving drum on which the latch cord is reeled. The added tension on the cord pulls the latch open as the dipper boom is moving forward.

Underground mining shovels are usually powered with electricity. Poisonous exhaust fumes and also the presence in mines of methane gas prohibit the use of internal combustion engines, while steam or compressed air would be impractical and inefficient. Electric current is furnished to this type of mine shovel by plugging-in a flexible cable.

Space restrictions require that the number of motors employed should be kept at a minimum. On the other hand, it is not desirable to use a great number of clutches in such a machine. All of the power is furnished by three dust proof a.c. reversing motors of the elevator type, having a starting torque of 220 per cent of normal. All of the motors are ball-bearing equipped and operate at a speed of 1,000 r.p.m. They are mounted on the turntable or superstructure.

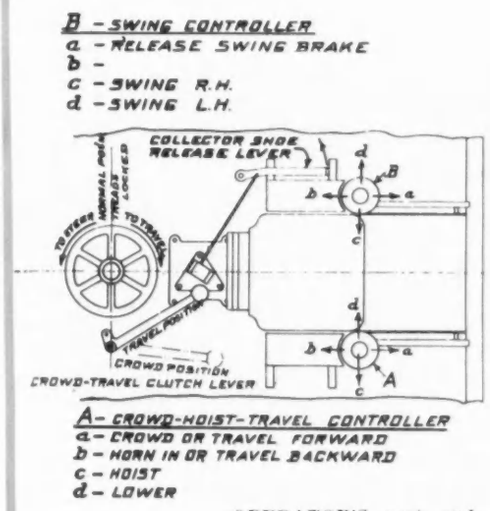
The entire control of the machine during the



PLAN AND ELEVATION showing compact arrangement of the units

working cycle is electrical except tripping the dipper. Greatest rapidity of manipulation in such a machine can only be attained by the quick stopping of all movements and the elimination of drifting. Therefore each motor has mounted on its armature shaft a magnetic solenoid brake which automatically releases only when the motor circuit is closed. The solenoid coils can be replaced quickly so that there will not be any protracted shutdowns because of the coils burning out. Limit switches shut off the current automatically when the boom crosshead reaches the limits of its travel, and also when the boom has been elevated to its maximum height. When the dipper hits the floor, and the hoisting cable slackens, a limit switch stops the motor automatically. All three motors drive through totally enclosed worm gear reductions. The whole electrical equipment is further safeguarded with the time-limit relays and fuses. Current at only 220 volts is used. The shovel is also grounded by a separate ground wire included in the feed cable. This insures safety of the operator against electrical shock.

One motor is used for both the horizontal travel of the boom structure and for propelling the continuous tread truck. A jaw clutch is mounted on each end of the extended armature shaft of this motor, the solenoid brake being located between the motor frame and a clutch located at the rear end of the armature shaft. The jaw clutch at the rear end connects to a worm reduction gear unit that drives the shaft on which the crown chain sprockets and fusee drum are mounted. On the forward extension of the same motor shaft is a jaw clutch for connecting to an-



OPERATOR'S seat and control levers. Letters designate direction hand switches are thrown for different movements

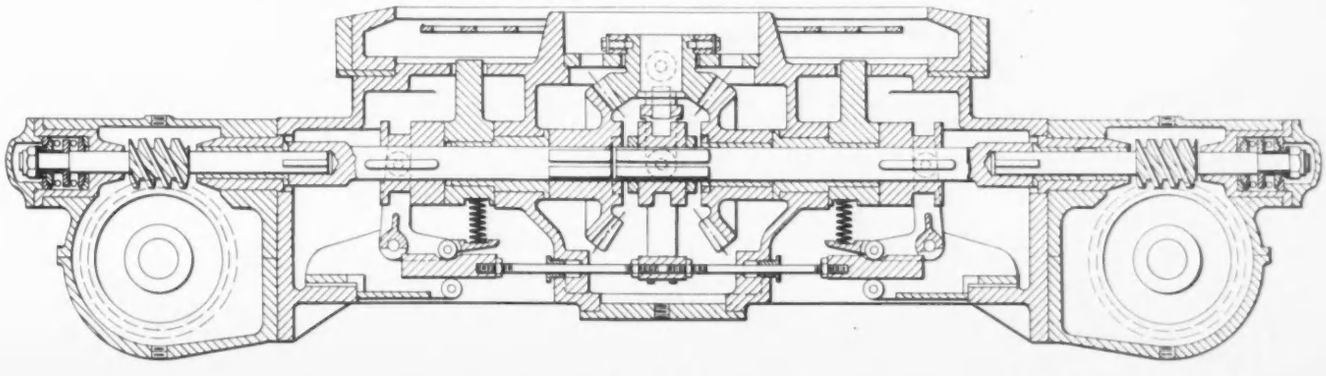
other worm gear speed reducer which, through gearing and shafts, drives the two tractor axles. The details of this drive are described below. A lever on the deck of the superstructure throws the two jaw clutches on the motor shaft simultaneously, one into engagement and the other out. Thus it is impossible to operate the crowd motion when the machine is traveling, and vice versa. Arrangement of the other two motors, one for the vertical movement of the boom and the other for swinging the turntable, are shown clearly in the plan view. The last motor is rated at 12 hp., while the other two motors are rated at 20 hp. each.

A mine shovel of this type having of necessity a relatively small dipper capacity, can be operated economically only when it is capable of being manipulated rapidly enough to give a large daily tonnage production. Therefore, the control of the machine must be simple and require a minimum of movement and strength on the part of the operator. Two levers, held in vertical or neutral position by springs, are located conveniently, one for the operator's right hand and the other for his left hand. The levers, which require only ¼ in. movement, operate switches in a ½ amp. secondary circuit that energizes magnetic contactors for the motor circuits. The four quadrant positions of each lever control the movements as designated in the accompanying diagram. Double contacts may be made at all four intermediate quadrant points of the right-hand control. Thus, with the right-hand lever any of the following combinations of simultaneous motion may be obtained: Crowding and hoisting, hoisting and retracting, retracting and lowering, or lowering and crowding.

Clockwise or counter clockwise rotation of the turntable is controlled from the left-hand lever. In the forward and rear positions of this controller the secondary circuit actuates a magnetic contactor which releases the solenoid brake on the swing motor, permitting the turntable to float. During the crowding operation, by means of electrical interlocks, the turntable is automatically kept free to rotate. Should the dipper hit a heavy piece of ore a glancing blow, the turntable will swing freely, thus preventing eccentric loads and their resulting stresses.

Details of the control and drive for traveling are shown in the section view of the truck. In order to travel, the operator throws a lever on the deck of the machine, making the hoist motor inoperative so that the dipper cannot be lowered during traveling. This same lever also throws in the jaw clutch on the forward extension of the crowd motor shaft and throws out the jaw clutch on the other end. The motor is then connected to the worm gear that drives, through bevel pinions, the central down shaft of the tractor. The section view of the truck shows how the drive is transmitted finally to the two tractor axles, driving the tracks at two diagonally opposite corners of the truck. This diagonal arrangement permits locating the tread take-ups, which allow 4-in. of

TWO BRAKES, held in contact by the spring acting on the bell-crank, are automatically released when the central jaw clutch is shifted to the left for travelling or to the right for steering



adjustment, at the other two diagonal corners.

Travel is controlled by the steering wheel shown. With the wheel in the neutral position the propeller shaft cannot rotate. For straight line travel, the wheel is turned clockwise, which locks the propeller shafts together, causing them to rotate in the same direction for straight line travel. The traveling speed is 50 ft. per min. Reversing the driving motor, reverses the direction of travel. Counter clockwise rotation of the steering wheel shifts the double jaw clutch on the propeller shafts, causing opposite rotation of the tractor axles, thus steering the machine. Reversing the driving motor steers the machine in the opposite direction. Actually, the machine turns almost about its own axis, a feature of very great value for working in close quarters.

On account of the conditions under which the machine must operate, all the gears are totally enclosed in water tight casings and all bearings are protected against the entrance of dirt. To minimize lubrication problems, all gears are run in oil. Ball or roller bearings are used wherever feasible. The worm reductions have phosphor bronze gears and hardened steel worms with bushed journals and ball thrust bearings. Low manganese steel castings and chrome manganese shafts, axles and clutches are used. No cast iron is used.

Net available lifting force at the lip of the dipper is 2 tons, but the average dipper load is only about ½ ton. A complete cycle of operations requires 30 sec., the machine therefore being capable of loading at a rate of 1 ton per min. Only one man is needed for operating. The machine has a maximum dumping radius of 14 ft. 4 in., and a working height up to 8 ft. 6 in. Its overall dimensions are relatively very small. Vertical height is only 7 ft. 1 in. For dumping at a height of 3 ft. 8 in. a minimum working clearance of only 7 ft. 6 in. is required. For traveling through a low drift the boom may be hooked up and the A-frame easily and quickly folded down, the machine then requiring only 4 ft. 10½ in. of headroom. The rear end of the turntable swings on a 6 ft. 3¼ in. radius, making is possible to operate the machine very close to mine pillars. The overall width of the machine is only 6 ft. 3 in. permitting it to pass through narrow spaces.

The total weight of the shovel is 13 tons. When it is to be moved to a distant place, it is run up a ramp and onto a special steel car truck which transports it to the new working place. The shovel is loaded on the car and unloaded under its own power.

On the Square

By Paul B. Swinton

DURING our discussion of a new design, I made a remark to Edwards, chief engineer of the Steel Specialties Company, that the circular and square cross-sections were the simplest.

"I agree with you as to the circle, but not in regard to the square," he replied. "In ordinary usage the square section is simple to handle, but it has a few peculiarities. In the first place, hold a square bar in a vise and hit the overhanging end a blow, and it bends crooked, that is, about one of the diagonals. The reason is simple enough. Figure it out, and you will find that the least moment of inertia in a square is that having a diagonal of the square for its axis. And the stiffness or resistance to bending is proportional to the moment of inertia.

"Now there is another peculiarity about the square cross-section. A square beam set on edge will be stronger if you plane off the top and bottom corners so that the vertical depth between the flattened corners will be about 85 per cent of the original diagonal. On account of the very small area of metal in the corners, cutting it away decreases the moment of inertia less in proportion to the decreased depth. Hence, the section modulus is increased.

"Another way of looking at it: Consider that when a beam bends, the metal in the section stretches and is stressed, within the elastic limit, in proportion to its distance from the neutral axis, in this case the horizontal diagonal of the square. Greatest stress would be at the top and bottom corners, but the area in the corners being very small, the effectiveness of this highly stressed material will be correspondingly small. Cutting away the corners subjects a greater area to the maximum stress. In addition to this, all points in the section from the neutral axis outwards are, for a given maximum stress at the outermost fibre, subjected to a higher stress when the top and bottom corners are cut away. The result is that the resistance of the bar to bending is greatly increased.

"Of course, a good design should never have sharp corners subjected to high stress, but it is interesting to note that cutting away the corners may even increase the section modulus."

"That sounds very much like saying a little man is stronger than a big one," I commented.

"He might be at that, if he were better proportioned," laughingly answered Edwards.

PROGRESS IN METALS

Physical Research and Practical Applications

A SURPRISINGLY small amount of attention was given at the A.S.M.E. annual meeting to new and improved engineering materials. Papers were practically limited to rather academic discussions of well-known alloys under high-temperature conditions, and of three cutting alloys which have been on the market for years. Prof. O. W. Boston presented additional data which he has obtained in extensive tests to show relative machining properties of various metals. There was little in the papers, in general, to give the designer or product development engineer any conception of the progress lately attained in the application of materials. A study of Professor Boston's paper, however, is valuable for the designer of metal-cutting machinery. While the results were only on cold-drawn steels, the comparative information is applicable to design as effected in the cutting of any material.

Research by Prof. A. E. White and C. L. Clark on the physical properties of the newer chromium-nickel and chromium-manganese steels at high temperatures, while duplicating somewhat the work done by manufacturer's laboratories, assembles the data into a continuous, comparative study. It is to be noted that the load-carrying ability of the chromium-nickel steels at high temperatures is superior to that of the chromium-manganese steels, although tensile strength seems to increase with the substitution of manganese for nickel. The use of stainless steels, chromium-nickel steels of the KA2 class, and other high-chromium alloys is increasing, and many of the difficulties in casting and machining them have been overcome, making an ever-broadening field for machine and equipment parts.

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ONE of the features of metal progress during the past year is the advance of the light alloys, notably those of magnesium. In eight years the consumption of magnesium for mechanical parts has increased about twenty times, and during the past year the price has dropped from about a dollar a pound to less than fifty cents. This reduction has come from the production developments and increased consumption, not from general market conditions. The use of magnesium alloys has extended from airplane engine pistons to wide use in reciprocating machine parts. This, because of the weight reduction, results in less wear and vibration.

Some of the magnesium alloys show surprising physical properties in structural parts, but where higher strengths are required, aluminum alloys are used. Overhanging parts, especially where the overhang must be counterbalanced, and parts that must be lifted by the machine operator, are now more and more made in the light alloys instead of in cast iron. Heat-treated magnesium-aluminum-manganese castings give strengths as high as those of good high-test cast iron without brittleness, and the stiffness of these alloys in the extruded form has been shown to be as much as eighteen times that of the same weight of ordinary steel. At present the largest part of aluminum alloy castings are in the aluminum-copper alloys, but there is a decided trend toward the aluminum-silicon alloys because of easier casting qualities, greater corrosion resistance, and lighter weight.

The high-strength cast irons, with and without special alloying elements, are finding increased use. Perlit, Aremite, Niresist, and Ironite, all placed on the market during 1930, are examples. Very high strengths are obtainable in these metals while the advantages of cast iron are still retained. With attention given to the alloying metals the designer can readily obtain the special characteristics, such as wear resistance, that he desires. Cast steel seems also to be entering a new era with the modern development of alloy cast steels that have tensile strengths well over 100,000 lb. per sq.in. and are very uniform. Improvement is due not only to the alloy elements, but to improved foundry methods, better deoxidizing and degasifying, and to regulated heat-treatment. There has been a healthy rivalry among steel foundries, iron foundries, malleable iron producers, and forgers that has resulted in the bettering of the products of all.

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RARE METALS have also entered a new stage of development and application. There is probably less tantalum in the earth than there is gold, but it is now being used to line valves and piping in chemical machinery because no single acid except hydrofluoric will attack it. The linings being put in acid-resistant parts are extremely thin, but they can be successfully welded into a solid unit. The tantalum has been coming from Australian tantalite, since the American columbite contains only about half as much of the metal. But if experiments now in process work out, the rare metal columbium, which predominates in the American ore, will be used extensively for such articles as watch cases, where the beautiful white color and absolute corrosion resistance will be valuable, and the metal tantalum will be a by-product instead of the reverse procedure which is now the case. Tantalum, which has a steel color, and is less attractive than columbium, is destined to find its greatest uses where high acid resistance and super-corrosion requirements are to be met, and where the cost will be warranted by the conditions. At present its price is about eight times that of silver.

Never before has color been so important in choosing metals and alloys for mechanical and electrical uses. A high-priced camera recently placed on the market has no plated parts, all being made of alloys whose color is carefully regulated by the alloy content. Hardware designers are likewise featuring "all-the-way-through" colors by adding nickel, cobalt, or other metals to the brasses and bronzes used for casting the articles. With proper mixtures of the white metals almost all shades can be obtained, and the stainless steel trim of buildings is being matched in nickel brass hardware without recourse to plating.

FRANKLIN ENGINEERING STRESSES

By Edward S. Marks

Chief Engineer, H. H. Franklin Manufacturing Company

AS AN organization, the Franklin engineering department has been found by experience to function smoothly and efficiently. A glance at the accompanying chart shows that its work is divided more or less according to units or major assemblies of the car, rather than by models of complete cars. This has the important advantage of giving each engineer a detailed knowledge of his specialty, and is a definite help in aiding him to benefit by accumulated experience.

From the chart it is apparent also that we are laying much stress upon smart appearance in our product. About half of our engineering staff concerns itself partly or wholly with this phase of our work, for we recognize that it has a most important effect upon sales. Our stylist, who is a well known body designer of experience, gives all of his time to items affecting appearance, such as the lines of the car and its appointments. Other body engineers deal with color, trim, finish, and related items, as well as with structural considerations.

Although we do not manufacture our own bodies, all except our custom bodies are made to our own designs and specifications in every detail, and are painted and trimmed in our own shop. Contact and co-operation maintained with suppliers closely approximates that which would be maintained were all work done in our own body shops. Our body engineers also work in close cooperation with sales and other company executives to make sure that such items as color of finish and upholstery meet the rapidly changing requirements of customers who are interested in these items and their bearing upon style and appointment.

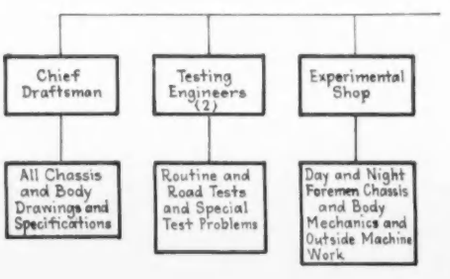
As the organization chart shows, our stylist and custom body engineer report directly to the chief engineer. The stylist serves largely in an advisory capacity, although constantly working with other body engineers, who must supervise all details of construction, and contact directly or indirectly through the assistant chief engineer with chassis engineers on all items that affect both body and chassis.

Edward S. Marks, Chief Engineer of Franklin, is also the nominee for Vice-President representing passenger car engineering of the Society of Automotive Engineers

Engineers who may be accustomed to think of an automobile body merely in terms of external and interior appearance may be surprised at the importance attached to it in an automobile engineering department. In reality, such a body is a complex structure, subjected to severe stresses and involving so many items which affect user satisfaction directly, that it merits fully, all the engineering attention bestowed upon it.

Design, test, and development of the Franklin chassis and its various units are not neglected by any means. They receive constant attention from

ORGANIZATION chart of the Franklin engineering department


Chief Draftsman
Testing Engineers (2)
Experimental Shop
All Chassis and Body Drawings and Specifications
Routine and Road Tests and Special Test Problems
Day and Night Foremen Chassis and Body Mechanics and Outside Machine Work

APPEARANCE

ten or more engineers whose functions are outlined in the chart and who work under direct supervision of the assistant chief engineer, though reporting in some cases on particular problems or projects directly to the chief engineer.

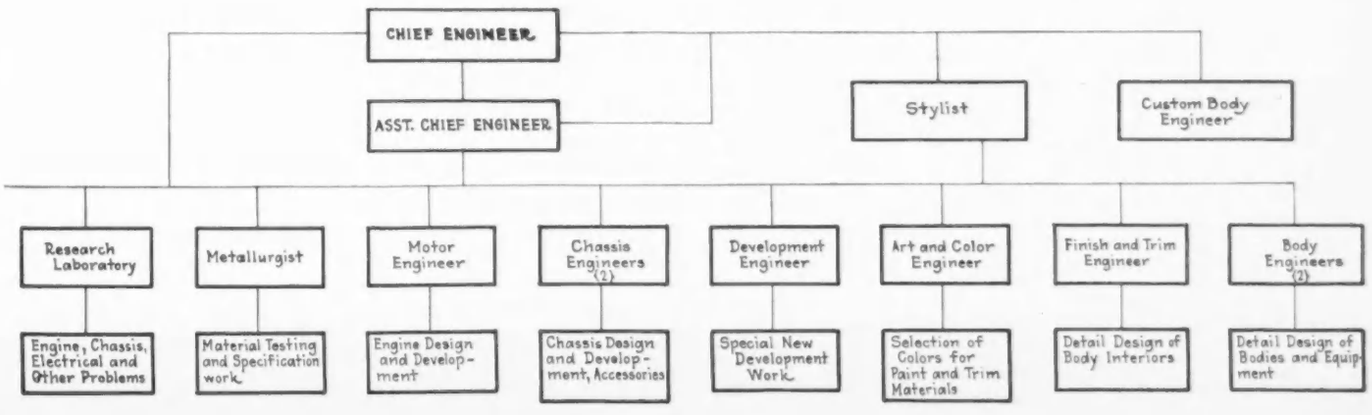
Each of the engineers concerned with chassis work, as well as the body engineers, have fairly well defined functions, but specific jobs are assigned either by the chief or assistant chief engineers, as occasion requires, and several of the group have authority to make requisition, subject to approval of the assistant chief engineer, for certain work by others in the group. Thus, for example, the motor engineer may call upon the chief draftsman, test engineers, experimental shop, or laboratory for work in their particular fields, or upon one of the chassis engineers for items that involve both engine and chassis.

Major design work on chassis units is handled chiefly by the motor engineer and two chassis engineers in cooperation with the chief draftsman. Experimental construction, including much of that on bodies, is done by our experimental shop or through it by outside shops. Tests required are conducted either in the research laboratory, the metallurgical laboratory, or under two engineers in charge of road tests on various cars. The development engineer is to some extent a free lance, reporting mostly to the chief engineer on particular new problems, such as the blower for cooling air, which in the new design recently developed consumes less than half the power formerly required, yet has an increased output.

All drawings for production items are discussed with the production department to assure moderate manufacturing costs prior to final approval by the chief engineer. They carry full specifications as to size and material which must be met by the purchasing department in buying from outside sources. New materials or equipment offered from outside sources must undergo test and be placed on the approved list before purchase for production cars is possible.

Most of the engineers are requested to write weekly reports to the assistant chief engineer on work completed or in progress. Significant items in these reports are combined by the assistant chief engineer into a report made to the chief engineer, who in turn reports to the general manager of the company. This not only provides a permanent record for reference by those interested, but enables those in authority to keep track systematically of the status of projects in progress.

Aside from customer contacts made through sales channels, a systematic effort is made to keep the engineering department in active touch with service problems. To this end a department for servicing customer cars is maintained at the factory under close supervision of two test engineers who promptly report any defects or difficulties encountered, so that immediate steps can be taken to avoid similar faults in future production. Reports from field service departments, also, are followed carefully, with a view to eliminating all possible occasion for customer dissatisfaction.



Books for Engineers

SHEET STEEL AND TIN PLATE. *By R. W. Shannon. 285 pages, 6x9 in. Indexed. Cloth board covers. Published by the Chemical Catalog Company, Inc., New York, N. Y. Price $5.*

WHILE this book is a specialized text, it will be found of considerable interest to the engineer and designer in general fields because of the present universal employment of sheet steel and tin plate.

The first three chapters review the whole subject of iron and steel, including definitions of the various types of steels. The book then takes up progressively the principles of rolling sheet steels, the continuous rolling of sheet, hot-rolling, annealing, cold-rolling, and metallic coating processes. The appendix includes material to aid the purchaser in the specification of sheet-steel products. "Sheet Steel and Tin Plate" is a book that should find frequent use in any engineering-department library.

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HANDBOOK OF CRANE INFORMATION. *By M. F. Beetham, Crane Engineer, Whiting Corporation. 147 pages, 5x7¾ in. Semi-flexible covers. Published by the Whiting Corporation, Harvey, Ill. Price $2.*

THIS comprehensive little book is a compilation of data and formulas entering into the selection and design of various types of cranes. According to its publishers, it represents the results of some thirty-five years of experience in crane manufacture. Diagrams, tables, and design formulas are used throughout, showing standard clearances for overhead electric traveling cranes, general dimensions of gantries, ranges of speed, duty, and cycle analysis for cranes, and design of runways, bridges, trolleys, and other crane details and accessories.

✦

ELEMENTS OF MECHANISM. FOURTH EDITION. *By Peter Schwamb, Allyne L. Merrill, and Walter H. James. 365 pages, 6x9 in. Cloth board covers. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y. Price $3.50.*

THE fourth edition of this well-known college textbook contains a few relatively minor changes from the previous edition. Thus, the subjects of chain drives and universal joints have been given additional attention, reflecting the increasing importance of these two machine elements.

The book covers the field of mechanical movements, and treats the subject by studying the motions of fundamental machine elements acting in various combinations. Both graphical and algebraic methods of analysis are presented. A great number of illustrative problems and their solutions are given throughout the text. This is of particular value to designing engineers who wish to use the book for reference purposes, for which it is well adapted.

STRENGTH OF MATERIALS. VOLS. I AND II. *By S. Timoshenko, professor of engineering mechanics, University of Michigan. 362 and 364 pages, respectively, 6x9 in. Cloth board covers. Published by D. Van Nostrand Company, Inc., 250 Fourth Ave., New York, N. Y. Price, Vol. I $3.50, Vol. II $4.50.*

THE author has done a notable piece of work in bringing together in two volumes a very comprehensive presentation of both the elementary and the advanced theories of mechanics. The first volume contains, according to the author's preface, principally material which is usually covered in courses in our engineering schools. In the opinion of this reviewer, very few engineering schools give undergraduate courses which treat the subject in the thorough and extended manner presented by the author. Though confined mostly to the elementary phases, the subject is treated more comprehensively and thoroughly than is usually found in such textbooks. Solutions to practical problems, some of an advanced nature, are given throughout.

Volume II, devoted to advanced theory, was written primarily for advanced students, research workers, and designers, and treats of the more complicated phases of the subject, such as curved beams, thin plates, buckling, and stress concentration. The concluding chapter deals with the mechanical properties of materials.

Designing engineers will find these two volumes valuable for reference purposes and advanced study. The great number of solved problems contained in each volume aid considerably in understanding the subject matter presented, and may be used as a check to verify the proper use of the formulas by which analytical methods are substituted for empirical design.

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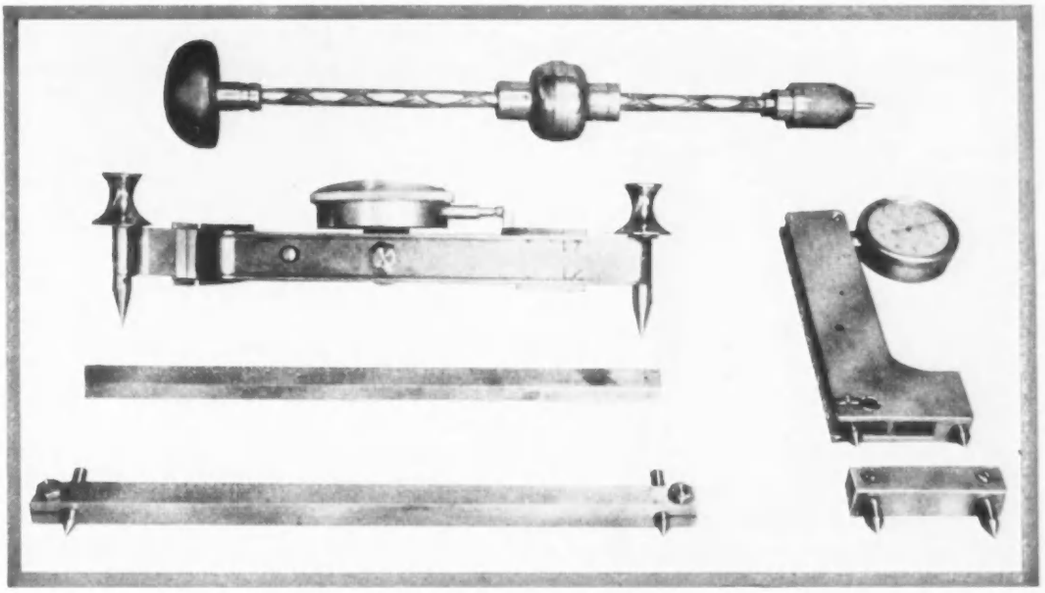
THE CONSTITUTION OF STEEL AND CAST IRON. *By Frank T. Sisco, Metallurgist, 332 pages, 6x9 in. Cloth board covers. Published by the American Society for Steel Treating, 7016 Euclid Ave., Cleveland, Ohio. Price $3.*

ENGINEERS who feel the need of reviewing, or perhaps bringing up to date, their knowledge of the physical and chemical structure of steel and cast iron, and the effect thereon of various heat-treatments, will find this book helpful, especially in these days when at least a speaking acquaintance with the terminology of the metallurgist is an asset to any engineer.

Although called an "elementary discussion," and written in terms which engineers with a background of technical education will not find it difficult to follow, the book is sufficiently advanced to merit study by any engineer who does not already possess a thorough knowledge of the subject treated. It was, in fact, written originally in the form of 24 educational articles which have appeared in the Transactions of the American Society for Steel Treating. There is, however, no lack of continuity, for the articles were planned to constitute the present volume.



Stress Analysis by Strain Gages

DESCRIPTIONS of typical strain gages appeared in the April number of Product Engineering. In this article, the author shows how to use these instruments and how to interpret the resulting data for analyzing the stress distribution in old and new designs.

By T. W. GREENE

Development Engineer,
The Linde Air Products Company

STRAIN gages, under certain conditions, afford the engineer a simple and convenient means of determining stress distribution in structures. They may be used both for checking the design and for effecting improvements in future designs by strengthening weak sections to obtain the ultimate of economical design—all parts of the structure of equal strength. The use of the strain gage is not limited, as is too frequently believed, to the laboratory alone, but can be used in the field to measure stress distribution in a structure after it is fabricated, even after it is in service.

Strain gage analysis is based upon the fundamental relationship between stress and strain. When a load is applied to an elastic body, the body stretches or deforms. As long as the proportional limit of the material is not exceeded, the strain will be proportional to the corresponding stresses set up in the material, and when the load is taken off, the body returns to its original form. In Fig. 2 is shown the relationship between stress and strain, typical of 0.10 to 0.20 carbon steel when subjected to a one-dimensional stress. It will be seen from this curve that for a stress of 10,000 lb. per sq.in. each inch of metal will elongate if the load is tension, or shorten if compression, approximately 0.00033 in., and for 30,000 lb. per sq.in., approximately 0.001 in., or three times as much. Thus, if the deformation of the metal is accurately measured, the stress, if of a single dimensional nature, can be calculated by the simple formula:

$$s = eE$$

where s = stress in lb. per sq. in.
e = unit strain in in. per in.
E = Modulus of elasticity (approximately 29,000,000 for steel)

The constant relationship between stress and strain ceases when the proportional limit of the material is exceeded. Consequently, the measurements of the deformation of the material after the proportional limit is exceeded cannot be evaluated in terms of stress, their only value being to indicate the relative deformation of the elements in different parts of the structure. On release of the load after the material is stressed beyond the elastic limit, the original elasticity generally returns below the elastic limit though the material does not return to its original length. The difference in the length of the body as a result of stressing above the proportional

limit, as illustrated in Fig. 1, is known as a permanent set.

Strain gages are instruments for measuring the strain produced in the material when a structure is subjected to a load. As the deformation is very small, the instruments must of necessity be sensitive and accurate. Several types of strain gages are described in an article in the April, 1930, number of *Product Engineering*. Essentially they consist of two conical prongs or metal points for contact of the instrument with the material, one point being movable in reference to the other. Its movement is greatly magnified, either directly or through a multiplying lever system, for recording on a dial gage or other sensitive indicator. Thus, deformations can be measured accurately and conveniently. The instrument is usually held in the hand and applied successively to the gage lengths under observation by inserting the conical steel points into drilled holes.

THE procedure and method of taking strain gage measurements is simple, although often sufficient care is not exercised to obtain accurate readings. The results obtained when improper or careless preparation and method of taking the readings have been followed are not only of no value, but if accepted will give misleading interpretations. One fault of many investigators lies in attempting too many observations. It is better to make only a few determinations at anticipated critical points and make these observations accurately than to make a large number, which, even if they should be accurately and tediously taken, are duplications and of little informatory value.

As stated, strain gage measurements are simply measurements of exceedingly small deformation of the material in the gage lengths under observation. The magnitude of this movement for 2-in. gage length is only 0.0002 in. for steel under a stress of 3,000 lb. per sq.in.

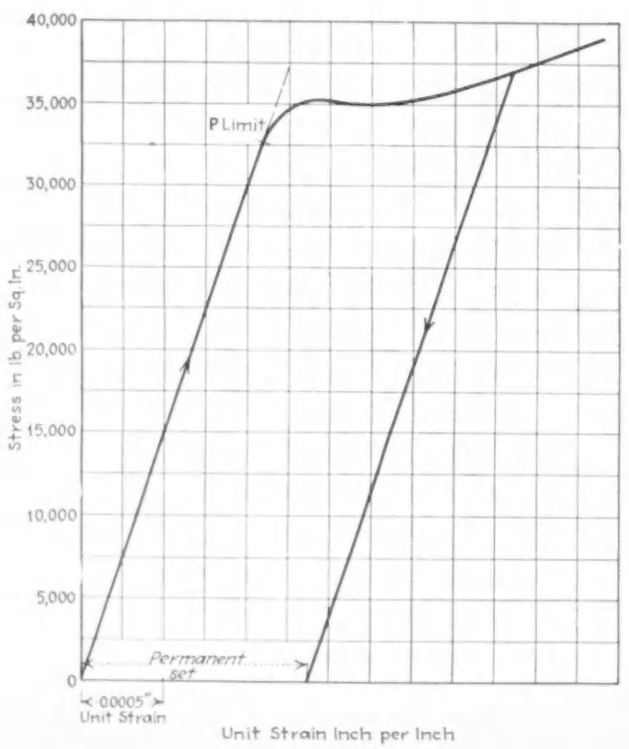


Fig. 1
TYPICAL stress strain diagram. Low carbon steel

Thus, to measure such minute movements there must be no error or variation in the contacts of the instrument with the material. To accomplish this, small holes must be drilled accurately at a correct distance apart in the material. If properly drilled the conical points of the strain gage can be repeatedly seated in the same pair of holes without changing the reading when conditions remain constant. With proper holes the instruments can be moved and seated in other gage-length holes for observation so that several points can be investigated with the same instrument. The procedure recommended in drilling the holes is to remove all paint, scale, and rust at the points where the holes are drilled. A small area about $\frac{1}{2}$ in. in diameter should be ground, filed, or lightly hammered with a ball peen hammer so as to present a flat surface for drilling the perpendicular hole. These areas can be located with the double punch standard gage supplied with the strain gage. After the surface is cleaned, gage points should be accurately punched, using the double punch standard. The prick punching should be very light, just large enough to be seen and guide the drill.

The holes should be approximately $\frac{3}{64}$-in. in diameter, or about the size obtained with a No. 56 drill. The holes need not be more than $\frac{1}{16}$ in. in depth. A reciprocating drill is recommended. The usual hand drill with the bevel gear drive on the side is unsatisfactory as it is practically impossible to steady the drill to give a true hole. Also, the usual twist drill is too flexible for this work. A small center drill having the drill portion about $\frac{3}{64}$-in. in diameter is recommended. The center drill has the necessary body stock, can be accurately chucked and will give a true hole, whereas the usual twist drill will give a slightly elliptical hole, which materially influences the accuracy of the reading.

Too much emphasis cannot be placed on the importance of drilling accurately the gage holes. The foundation of strain gage readings, in fact the whole investigation, is based on the accuracy with which these holes are drilled. The holes should not be beveled, the best results being obtained when the edges are at sharp right angles to the surface. It is desirable after drilling to turn the conical points of the double punch gage around the hole a few times; this will wear off any very slight burrs that may affect the readings. Before taking observations the strain gage should be inserted in the holes at least a half-dozen times in order to wear a natural seat and to observe if the readings repeat. If the readings vary, new holes should be drilled.

IN taking readings, the procedure is to take first the zero readings on the standard reference gage which consists of two accurately spaced holes in the punch frame supplied with each instrument. The readings should then be taken at all the gage points of the structure and the zero readings rechecked on the standard reference gage to see if any change has occurred in the zero reading. The dial should then be turned or set to compensate for the differences in the zero readings and all the strain gage readings taken again. This should be repeated several times until the variation in the successive readings at any gage point is less than half the division of the dial. This same procedure, of course, should be followed for each increment of loading.

A temperature change during strain gage observation materially affects results. A 10-deg. temperature change produces in steel a change in length of approximately 0.000066-in. per in. Thus any temperature change dur-

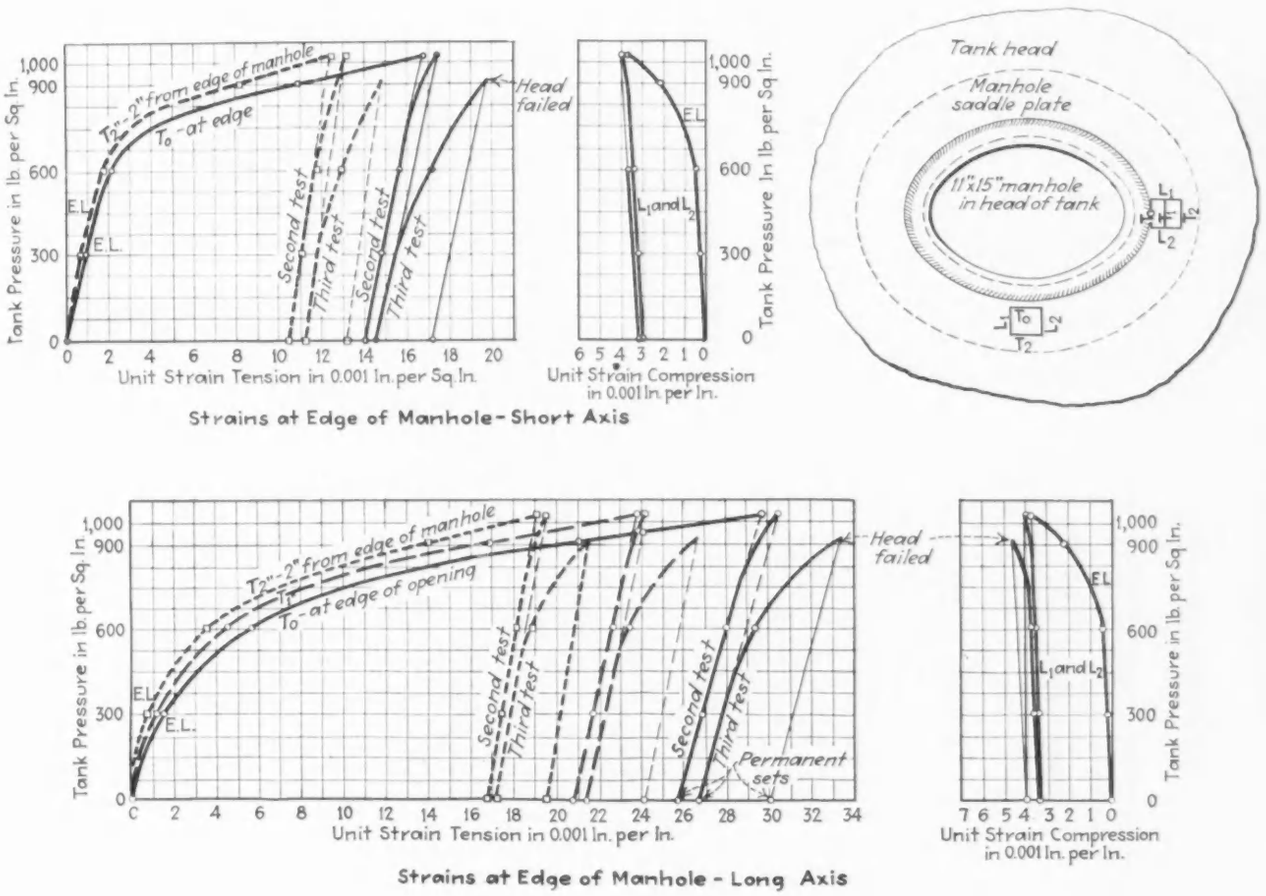

Tank Pressure in lb. per Sq. In.
1,000
900
600
300
0
T_2 - 2" from edge of manhole
T_0 - at edge
E.L.
E.L.
Second test
Third test
Second test
Third test
Head failed
0 2 4 6 8 10 12 14 16 18 20
Unit Strain Tension in 0.001 In. per Sq. In.
E.L.
L_1 and L_2
6 5 4 3 2 1 0
Unit Strain Compression in 0.001 In. per In.
Strains at Edge of Manhole - Short Axis
Tank head
Manhole saddle plate
11"x15" manhole in head of tank
L_1
L_2
T_0
T_2
T_2 - 2" from edge of manhole
T_0 - at edge of opening
Second test
Third test
Second test
Third test
Permanent sets
Head failed
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34
Unit Strain Tension in 0.001 In. per In.
7 6 5 4 3 2 1 0
Unit Strain Compression in 0.001 In. per In.
Strains at Edge of Manhole - Long Axis

Fig. 2

STRAINS at edge of manhole showing cause of failure as revealed by strain gage tests

ing observations may introduce a decided error in measurements. Wherever possible, the structure should be at approximately the same temperature throughout the time of observation, if necessary, postponing the tests until this condition exists. If the standard reference gage is of the same material as the structure and is placed on the structure, it will somewhat compensate for temperature change, provided that no temperature stresses be set up.

IN a large structure it will usually be impossible to measure the stresses in the beams and columns caused by the dead load. It will only be possible to measure the stress caused by the actual live load or assimilated live load. If, however, the initial strain gage readings were taken before the column or beams were erected, and the readings taken again after the structure is completed, it would be possible to determine the dead load stresses, as well as any live load.

The head of a large oxy-acetylene welded tank was subjected repeatedly to a hydro static pressure of 900 lb. per sq.in., three times the design working pressure of 300 lbs. per sq.in., and tested by means of strain gages. This vessel was 5 ft. in diameter, 42 ft. in length, having a shell plate thickness of $1\frac{1}{8}$ in., and manhole head of $1\frac{1}{4}$ in. The stresses set up around the opening were found to be exceedingly high by strain gage measurements. In fact, the readings showed that the metal yielded continually under each application of the test pressure, which condition would inevitably lead to failure. The strain gage measurements are shown plotted in Fig. 2. As a result of such strain gage investigations, fabricators have set about strengthening such openings.

Another important development in connection with strain gage investigations, principally as a result of testing oxy-acetylene welded vessels, has been in the design of pressure-vessel heads. The practice in the past has been to use heads dished to a radius equal to the diameter of the tank, and with a sharp radius knuckle where the head joins the cylindrical shell. Strain gage measurements have shown the stresses to be exceedingly high, particularly on the inside surface at the knuckle where fatigue cracks cannot be so easily detected. This investigation has led to changes in codes and specifications for pressure-vessel designs in which ellipsoidal shaped heads are required instead of the former standard type. Strain gage investigations of ellipsoidal shaped heads having a ratio of axes of 2 to 1, or depth of dish of one-quarter the diameter of the tank, have shown the maximum stress approximating the stresses elsewhere in the shell.

ELECTRIC MOTORS for Special

APPEARANCE and compactness frequently demand that the motor be incorporated as an integral part of the machine. Special motors must be built to meet special conditions, both as regards electrical characteristics and mechanical design. Motor manufacturers have taken the lead in making it possible for the designer of motor-driven machinery to procure the best motor that will meet specific requirements. All progressive manufacturers of electrical motors offer engineering service to assist the designer in specifying his motor. As one chief engineer in charge of motor design said, "All that our customer's designer need do is tell us what he needs a motor for, and we will design the motor to meet his specifications."

It is the purpose of this series of articles to present to the designer of motor-driven apparatus some of the things that have been done and are being done in semi-standard and special motors. Standard stock motors will also be referred to. Typical examples of various designs will be illustrated and described.

The very smallest motors are usually special, though some of them have been so designed that they lend themselves readily to general application. These small motors include those for meters, instruments, toys, phonograph turn tables, and similar devices. One of the most common applications for this type of motor is in electric clocks.

In the accompanying Fig. 1 is shown a phantom view of the Telechron motor, manufactured by the Warren Telechron Company, for driving electric clocks, recording meters, elapsed time recorders, and other recording instruments involving the time element. Its speed of rotation is solely dependent upon the frequency of the energizing alternating current. Most power systems maintain the current frequency at a specific average value by means of a master clock. This keeps the synchronous motor driven device in exact time, and by virtue of the refinements in the electrical design of the motor, synchronous speed will be maintained even when the voltage drop exceeds 25 per cent and temperature conditions vary from 0 to 100 deg. F. Special motors can be furnished for operation at sustained temperatures even outside this range.

Electrically, Telechron motors consist of a two-pole field excited by a coil drawing power from a single-phase a.c. circuit. Copper shading coils on one of the pole arms give a rotating tendency to the magnetic field by causing the flux through that arm to lag behind. This causes the rotor, comprised of thin, hardened magnet steel having exceptionally high magnetic remanence, to rotate, its polarized section tending to follow the rotating flux. The speed of rotation of this motor is 3,600 r.p.m., this being reduced to the desired amount through a train of gears.

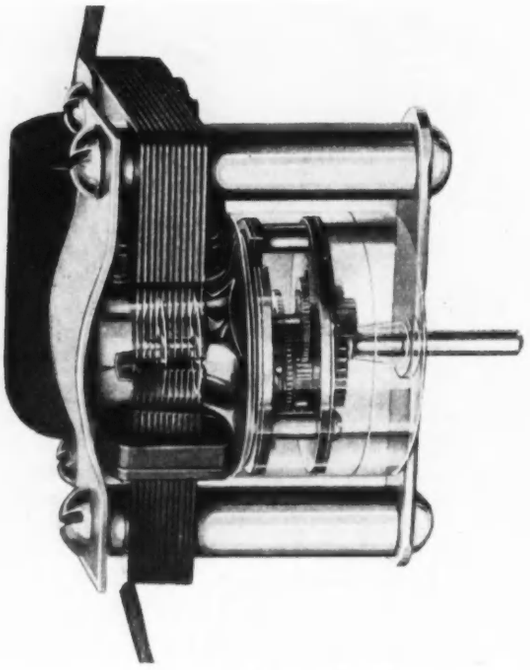


Fig. 1
ALL MOVING elements of the Telechron motor shown in phantom view are inclosed in a sealed brass case

All rotating parts of the Telechron motor are enclosed in a tightly sealed brass case, the neck of the casing containing the rotor. Like the General Electric refrigerating mechanism, no oiling is required, as sufficient oil for the life of the motor is supplied at the time of manufacture. The com-

Applications

The first of a series of articles dealing with semi-standard and special motors built into electrically driven devices and machines. In this article, small motors for clocks, recording instruments and light power requirements are considered.

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plete sealing eliminates all possible trouble that might arise from dust collecting on moving parts.

Normally, the direction of rotation of the driving shaft of the motor is clockwise. However, the rotation may be reversed by inserting the motor casing on the opposite side and making the necessary changes in straps, posts, and other small parts.

Telechron motors are available as a standard article in several types and sizes, each designed for a certain specific field of operation. The light-duty type is suitable for small power requirements as in recording meters. Another type is made for larger power requirements as in multiple recording meters. One type is designed for greater power at one rev. per sec., and another to develop greater strength at slower speeds. Two of the available types are reversible motors.

A type of motor, made by the Diehl Manufacturing Company and used in the Grigsby Grunow Majestic combination radio and talking machine for driving the turntable, is illustrated in Fig. 2. It is an induction motor with squirrel-cage rotor having the slots skewed in order to obtain silent operation. One of the features is the governor and method of speed regulation. The governor weights consist of two brass cubes attached to each end of a flat strip, centrally mounted on the motor shaft. One face of the cubes is fastened against the face of the strip. The center of gravity of these weights being eccentric to the strip, the centrifugal force exerted on the brass weights puts an eccentric load on the strip, bending it slightly so that brake felts on the strip bear against a molded composition drum. In the central section of the illustration may be seen a portion of one of the governor weights extending out on the right side of the brake drum. The drum is mounted freely on the shaft but is prevented from rotating and held in its longitudinal position by an eccentric pin in the lower end of the vertical speed regulator shaft fitting into a mating hole in the hub of the brake drum. Moving the regulator arm slides the drum along the motor shaft, adjusting the distance between the brake felts and the governor arms. In this way a fine and positive adjustment for speed variations is obtained.

The motor has a one-piece cast-iron frame, and a one-piece ground shaft with a worm milled directly on the shaft. A Micarta worm wheel is used, insuring quiet operation, and is mounted on the vertical shaft, driving the turntable at 78 or

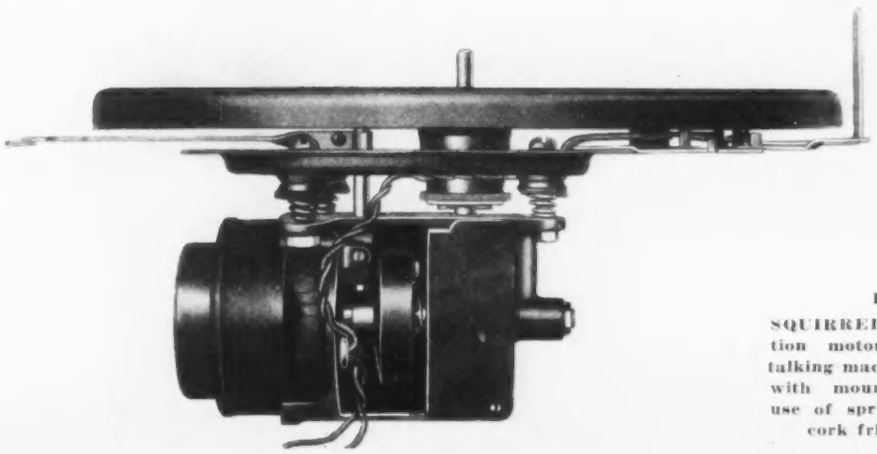


Fig. 2
SQUIRREL CAGE induction motor for driving talking machine turntable, with mounting showing use of springs, felt, and cork friction drive

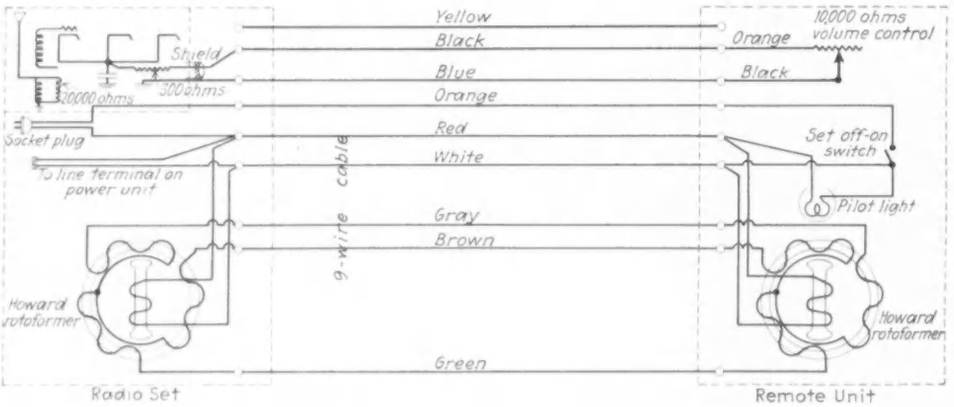


Fig. 4
SELF SYNCHRONOUS motors wired for operating remote control on radio. Only the five lower wires are required for the motor control

33 r.p.m., as may be required. The main motor bearings are Navy specification phosphor bronze, while the outer shaft bearing is polished cast iron. Both ends of the motor shaft bear against ball thrust bearings mounted to provide for end thrust adjustment. The net weight of the motor is 6 lb.

The motor is secured to a round steel mounting plate by a 3-point double spring suspension, with felt interposed between the springs and the mounting plate. This completely absorbs vibrations or shocks which would otherwise be transmitted to the turntable. A 6-in. round hole is cut in the motorboard, and the motor placed in position by fastening the mounting plate to the motorboard with four screws. The turntable is driven by a cork friction disk on the turntable shaft. This disk also acts as insulation against mechanical vibration and protects the motor shaft worm in case of accidental rotation of the turntable when the motor is not in operation, or when the turntable is stalled during operation.

Considerable attention has been paid to make the motor attractive in appearance. It is finished in durable black lacquer with all steel parts heavily nickel-plated to prevent rust, and the fittings finished in statuary bronze.

Another type of motor for similar purposes is that used for driving the Victor Radio with Electrola. This turntable driving motor is an induction disk motor similar in construction to the ordinary watt-hour meter motor used in measuring house current. The motor is constructed on a cast-iron frame at two opposite sides of which are mounted the inductors, each consisting of a current coil below and a voltage coil above. The rotor is merely a disk and is mounted on the shaft or turntable spindle, and, as shown in Fig. 3, rotates through the air gap between the current and voltage coils.

A fly-ball type governor driven off of the shaft by a worm drive maintains constant speed, a small metal disk at one end of the governor turning against a vaseline impregnated felt friction pad attached to the speed regulator arm. The pad is held against the rotating governor friction disk with a spring whose tension can be varied by turning the speed regulator screw. This adjusts the speed of the motor by regulating the pressure of the friction pad against the governor friction disk.

Inasmuch as the induction disk motor forms practically a purely inductive load, its power factor is consequently low. In order to obtain the additional power required for home recording on the new combination Victor Radio with Electrola instruments and still maintain the constant speed of 78 r.p.m., a 4½ Mfd. condenser is connected in series with the current coils during recording, and is shorted out of the circuit during the "play back" or when playing the ordinary records. Thus the power factor is raised when greater power is required for home recording, and lowered when less power is needed to play the records.

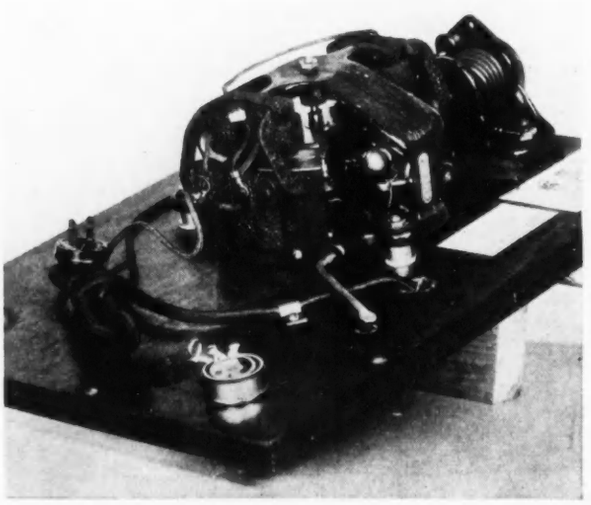


Fig. 3
MOTOR SHAFT drives turntable directly in this induction disk motor with fly ball governor

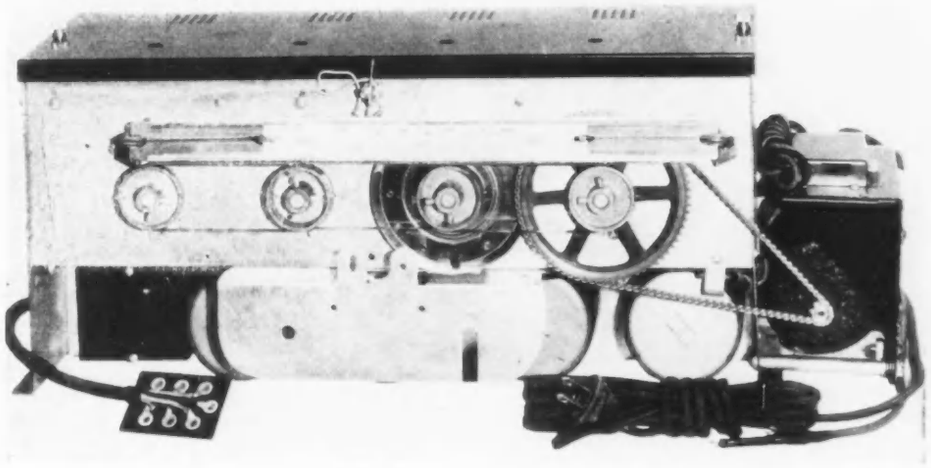


Fig. 6
ADJUSTABLE BRACKET mounting and chain drive of controlling motor on radio

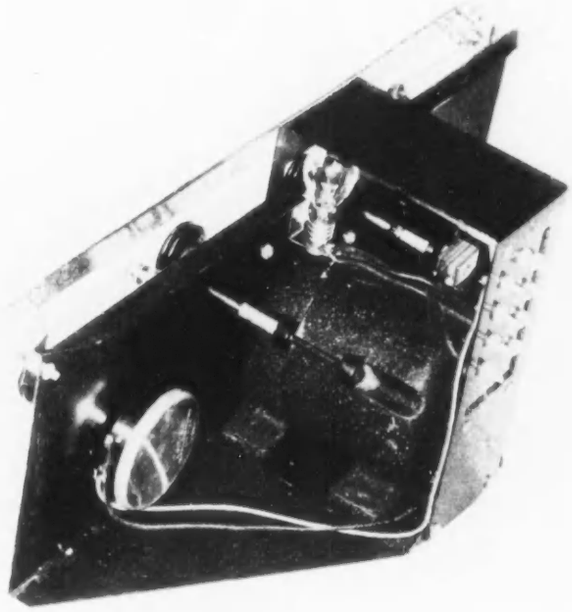


Fig. 5
MOTOR MOUNTING on remote unit for controlling radio

This type of motor also meets the essential requirements for turntable motors, namely, constant speed and silent operation.

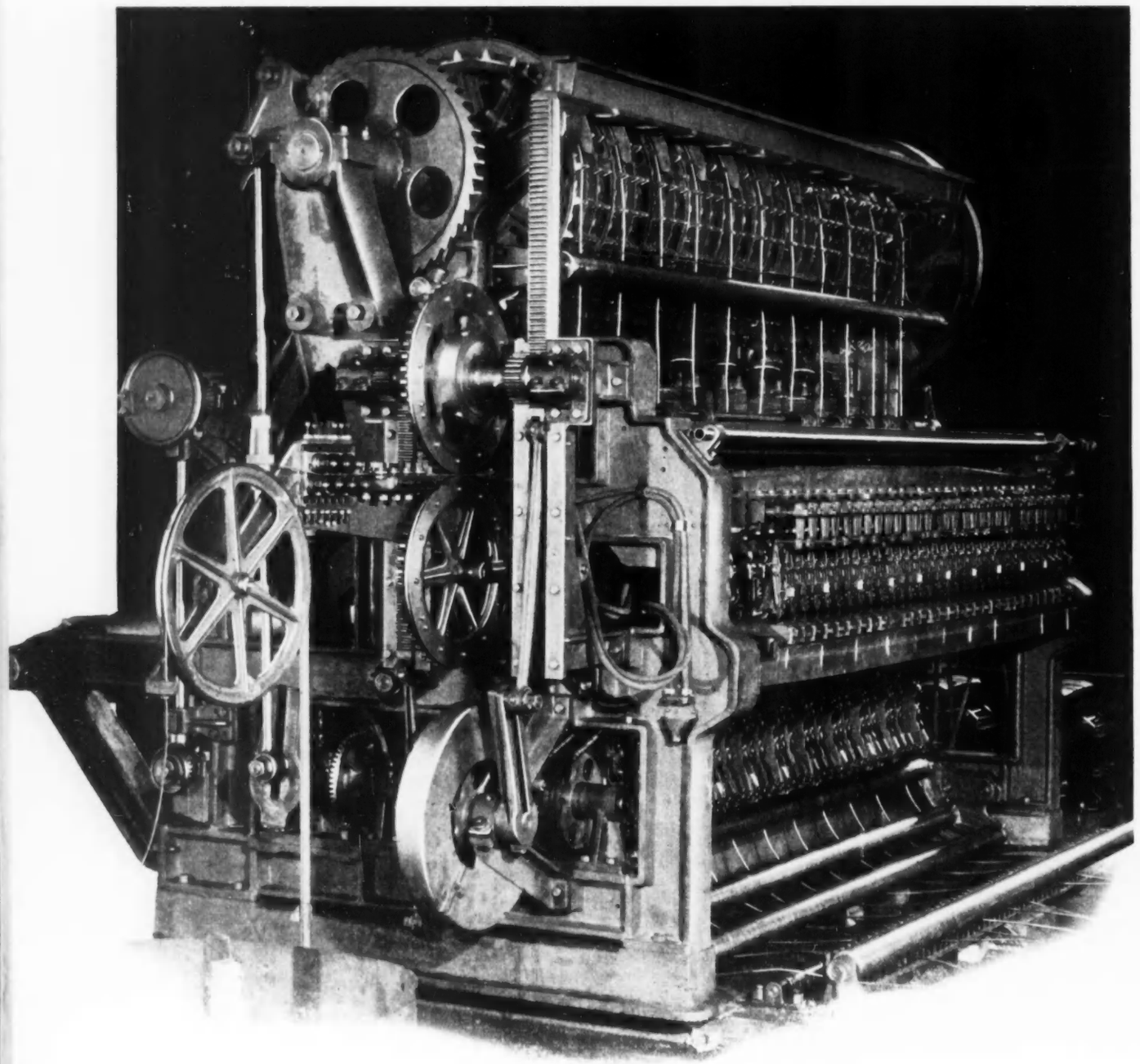
Sometimes it is desired to duplicate mechanical motions between distant points electrically, that is, without the interposition of mechanical linkages. Though patented originally in about 1894 by Nicola Tesla, it was not until comparatively recent years that the self-synchronous type of motor, capable of performing such duty, was applied commercially to any extent. Today it is being used to transmit water level indications in the locks of the Panama Canal to a central recording station, and in the U. S. Navy to relay instantly from the conning tower to the gun position definite information with reference to gun fire. The self-synchronous type of motor is also used to control the lighting in the Chicago Civic Opera House, to record boiler room instruments readings at a central point, to control valves, and what is probably its most generally known application, for the remote control of radio sets.

In Figs. 4, 5, and 6 are shown the wiring diagrams between the remote control and the controlled unit, a picture of the remote control unit, and the application of the controlling motor to a radio set, as manufactured by the Howard Radio Company.

The principle of operation of the self-synchronous motors or rotoformers is very simple. The three phase fields of the two motors are interconnected as shown. Voltage of a polyphase circuit or equivalent thereof is impressed on both armature windings, setting up a rotating magnetic field. Displacement of one armature sets up an unbalanced voltage, resulting in a current that serves to pull the armature of the other motor into the same position. With both armatures in the same position, the voltages are balanced.

Sometimes ball bearings are used in these motors. In the experience of the Howard Radio Company, a good bronze bearing will give less vibration. Also, a more accurate fit can be made with a properly machined bronze bearing than with a ball bearing. This is very important as it is essential that the gap between the rotor and the stator be kept close to specified tolerances in order to obtain accurate reset operation of the motors. For the same reason, a high grade of material and workmanship is required throughout the motor.

Incidentally, the requirement for sustained noiseless operation in small motors has resulted in the preference, by many manufacturers, for bronze sleeve bearings instead of ball bearings.



DESIGNED FOR HIGH PRODUCTION

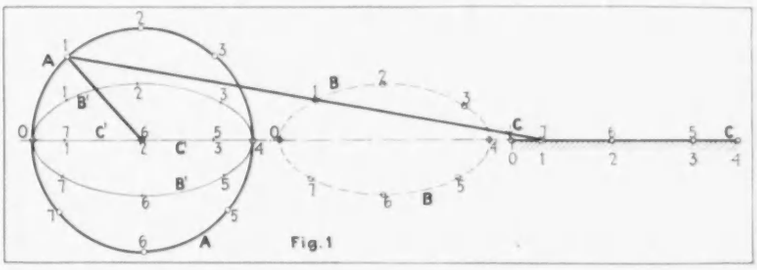
RATCHETS, adjustable eccentric motions, levers, bevel gears, racks and pinions, covered slides, and almost the whole gamut of mechanical devices are employed in this new Thomson-Gibb machine designed to weld automatically 151,000 sq.ft. (54 tons) of steel-wire fabric per 10-hour day. Hard-rolled copper block welding dies, readily replaceable, each set of dies connected to one of 37 transformers, make 37 welds simultaneously. The transformers have cast copper secondaries connected to water-cooled secondary bars. Much of the detail of the design can be distinguished in the illustration.

The machine can be adjusted to obtain the desired horizontal spacing of the longitudinal wires, which may be varied from 2 to 16 in. by ½-in. steps. Transverse wire spacing is adjustable by the intermittent feed. Fabric 100 in. wide, plus 2 in. overhang or selvage on each side, can be welded of wires varying in gage from No. 14 to No. 0. All material is fed to hardened straightening rolls from reels behind the operator or off at one side. Positioning is automatic. The transverse wires, fed from the side and sheared automatically, feed continuously through 330 deg. of the cycle, and are at rest for 30 deg. for cutting off. The longitudinal or strand wires feed during half the cycle, and are welded during the other half. One stay wire is fed into the machine while the preceding wire is being welded. Pressure switches control the welding current, no current being admitted until a predetermined pressure exists. Other hardened straightening rolls flatten the finished fabric as it leaves the machine. It is direct motor driven, and may take 450 Kva. at the moment of welding.

Superimposed Diagrams for Studying Link Motions

By G. B. KARELITZ

Associate Professor of Mechanical Engineering, Columbia University

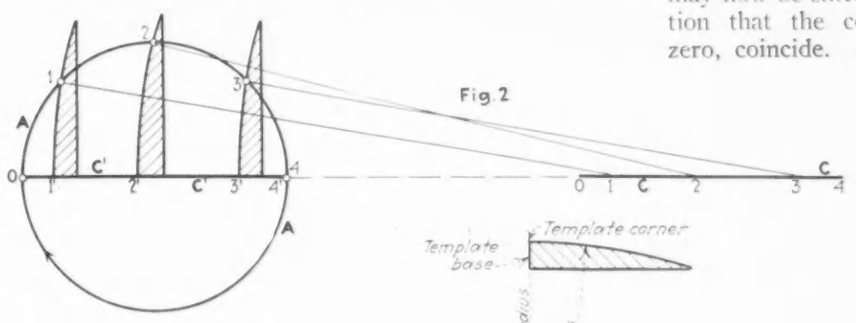


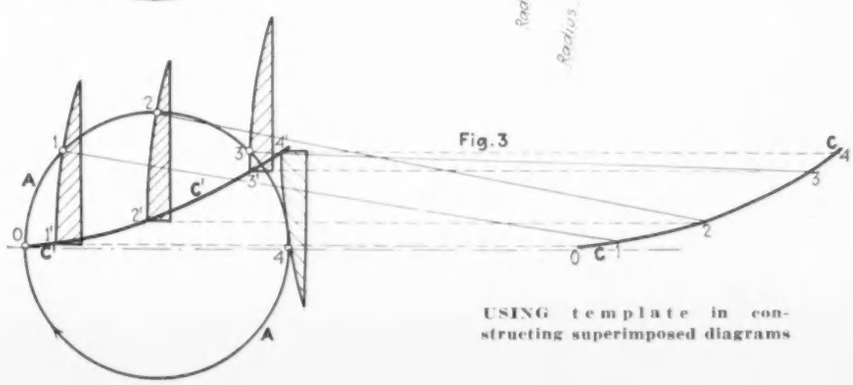
PATHS of points on the common slider-crank mechanism plotted in the usual manner and superimposed

FREQUENTLY, full-size plot of the motion of a link mechanism is required. As a rule, the mechanism is of a single degree of freedom, that is, the position of one link, called the reference link, defines completely the position of every other link of the mechanism. The following refers only to this type of mechanism, and further, only to those motions lying in parallel planes, this last permitting the paths of all points of the mechanism to be projected on one plane, such as the surface of the drawing paper.

To obtain an exact full-size diagram of the motion of various points of a mechanism, a full-size skeleton sketch is made with long straight edges and beam compasses on a large drawing board or on a floor. Successive positions of all links corresponding to various locations of the reference link are then obtained by construction. This process is impractical when mechanisms of large size are considered. However, a full-size diagram of motion may be constructed on a sheet of paper of a size just sufficient to contain the largest path of motion. The method, while not original with the author, is evidently not widely known.

Considering the slider-crank mechanism in Fig. 1, the path of three points, A, the mid-point, B, of the connecting rod, and C are plotted, the like numbers indicating corresponding points. The diagrams BB and CC may now be shifted parallel to themselves to such a position that the corresponding initial positions, marked zero, coincide. For this particular case, the diagrams CC and BB have to be moved to the left over distances equal to AC and $\frac{1}{2}\,AC$ respectively. The diagrams AA, $B'B'$ and $C'C'$ are then known as "superimposed diagrams."





USING template in constructing superimposed diagrams

Relations between the points of the diagrams AA and CC and the superimposed diagrams AA and $C'C'$, are shown in Fig. 2. It is evident that the points $1'$, $2'$, $3'$ and $4'$ are obtained by striking arcs of radius AC through points 1, 2, 3 and 4 of diagram AA and using points 1, 2, 3, and 4 of CC as centers. If a template such as shown in Fig. 2 be prepared, the points $1'$, $2'$, $3'$ and $4'$ can be obtained conveniently with this template. The base of the template is made parallel to the direction of shift of diagram CC, and the template must always

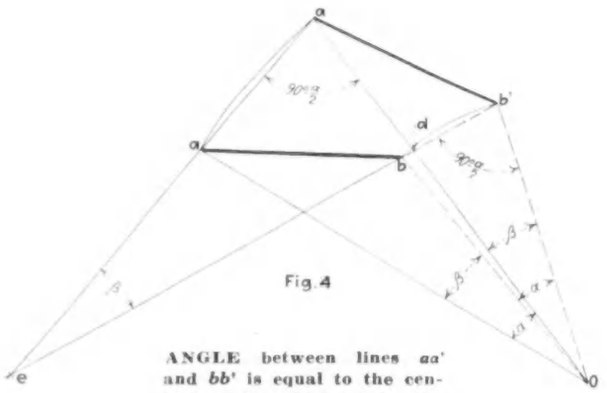


Fig. 4

ANGLE between lines *aa'* and *bb'* is equal to the central angle subtended by the two given link points

be held in that position. With its radius edge successively intersecting the path AA at 1, 2, 3 and 4, the lower left-hand corner of the template locates the points 1′, 2′, 3′ and 4′, respectively, of the superimposed diagram $C'C'$.

A similar construction is shown in Fig. 3, wherein end C of the connecting rod is guided on a radius. The diagram CC of the path of the connecting rod end C is shifted parallel to itself into position $C'C'$, the zero points O, of CC and AA being brought into coincidence. The maner of constructing the superimposed diagram by the use of the template is evident, the template corner indicating the corresponding points on the path $C'C'$.

In every case, the path $C'C'$ is drawn from the point O of path A parallel to and in the same direction as the known path CC. The line joining the initial points of paths AA and CC establishes the direction of shifting. The radius of the template is made equal to the length of the rod AC, to the same scale to which the path AA is drawn. The base of the template must be drawn radial. Keeping the base of the template parallel to the direction of shifting, and the lower corner on the path $C'C'$, the intersection of the radius edge with path AA locates the corresponding points of paths AA and the superimposed path $C'C'$.

The operation is facilitated when an adjustable T-square is used. Size of paper required is determined only by the paths of travel of the mechanism points and is independent of the length of the connecting link.

It will now be demonstrated and proven how the path of any point on the link AC may be plotted on the superimposed diagram. Any displacement of a link moving parallel to a plane may be reproduced by a rotation of that link about a center. In Fig. 4, the link represented by the line *ab is* moved to another position *a'b'*. Evidently the intersection of the perpendicular bisectors of *aa'* and *bb'* will be the center about which the link may have been rotated through the angle α in going from its initial to its final position. Let the central angle *aob*, be designated by β. As the isosceles triangle *bob'*, has an apex angle α, the angle *bb'o* is equal to 90 deg.—α/2. Similarly in the triangle *aoa'*, the angle *aa'o* is equal to 90 deg.—α/2. The opposite angles *b'do* and *a'de* are equal. Hence the triangles *odb'* and *eda'* are similar, and angle *a'eb'* is equal to angle *a'ob'*, that is, the angle between the lines *aa'* and *bb'*, connecting the initial and final positions of the link points *a* and *b*, is equal to the central angle *aob*, as shown.

In Fig. 5, the link $A_oC_oE_o$ has been moved to the position $A_1C_1E_1$, the point C_o moving along the path C_oC_1, and the point A_o along the arc A_oA_1. The path $A_oC'_1$ is drawn parallel and equal to C_oC_1, as in Fig 3. The superimposed diagram of point E is now obtained by shifting path E_oE_1 parallel to itself along E_oA_o to position $A_oE'_1$, making $A_oE'_1$ equal and parallel to E_oE_1. It will now be shown that the shaded triangle $A_1C'_1E'_1$ is similar to triangle $A_oC_oE_o$, that is, displaced points of the link when represented in the superimposed diagrams form a figure geometrically similar to the configuration of the corresponding points on the link itself.

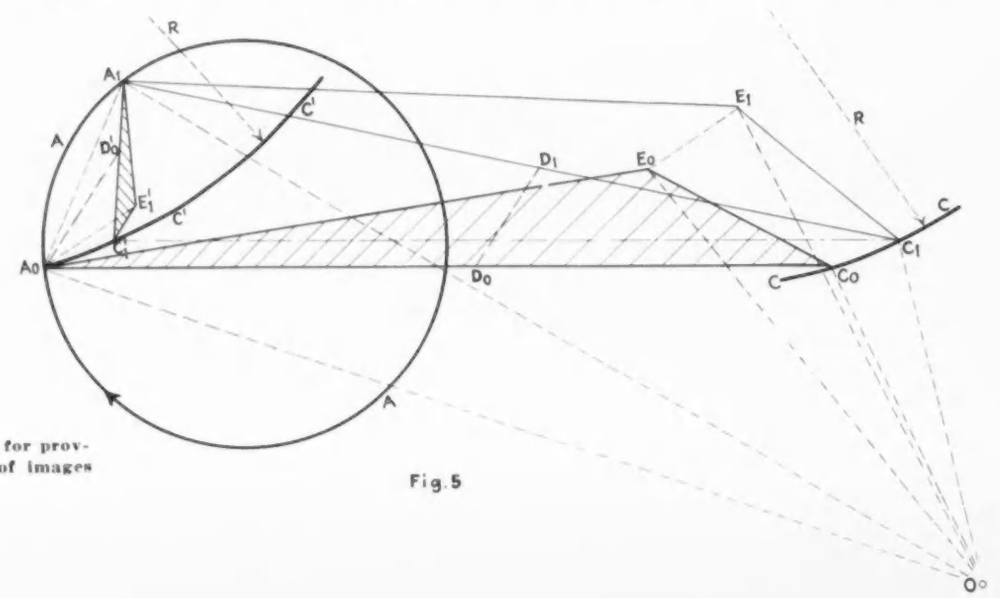
Displacement of link $A_oC_oE_o$ from its initial to final position is shown in Fig. 5 as being the result of a rotation about the center O. From the proof given under Fig. 4, the angles between the displacement A_oA_1, E_oE_1 and C_oC_1 are respectively equal to the central angles between the radii OA_o, OE_o, and OC_o, and by construction respectively equal to the angles between the vectors A_oA_1, $A_oE'_1$ and $A_oC'_1$. As the displacements of points in a rotating body are proportional to their distance from the center of rotation, we have:

$$\frac{A_oA_1}{A_oO} = \frac{C_oC_1}{C_oO} = \frac{E_oE_1}{E_oO}$$

as $C_oC_1 = A_oC'_1$ and $A_oE'_1 = E_oE_1$ by construction,

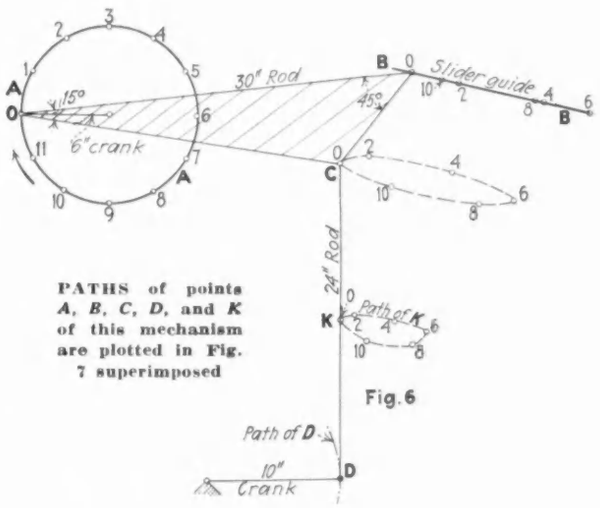
$$\frac{A_oA_1}{A_oO} = \frac{A_oC'_1}{C_oO} = \frac{A_oE'_1}{E_oO}$$

As two sides are proportional and the included angles equal, the three triangles having A_o for a common apex and the bases $A_1C'_1$, $A_1E'_1$ and $E'_1C'_1$ are respectively similar to the three triangles having O for a common apex and the bases A_oC_o, A_oE_o and E_oO_o. From this it follows that triangle $A_1C'_1E'_1$ is similar to triangle $A_oC_oE_o$, the two triangles being shown cross-hatched in



CONSTRUCTION for proving the theorum of images

Fig. 5



PATHS of points *A*, *B*, *C*, *D*, and *K* of this mechanism are plotted in Fig. 7 superimposed

Fig. 6

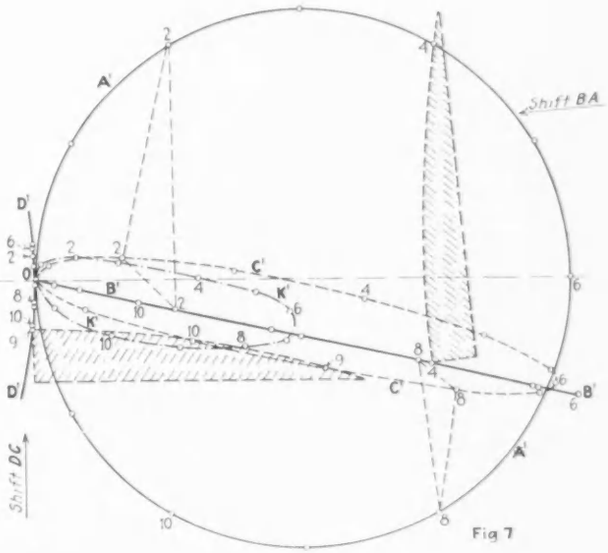


Fig. 7

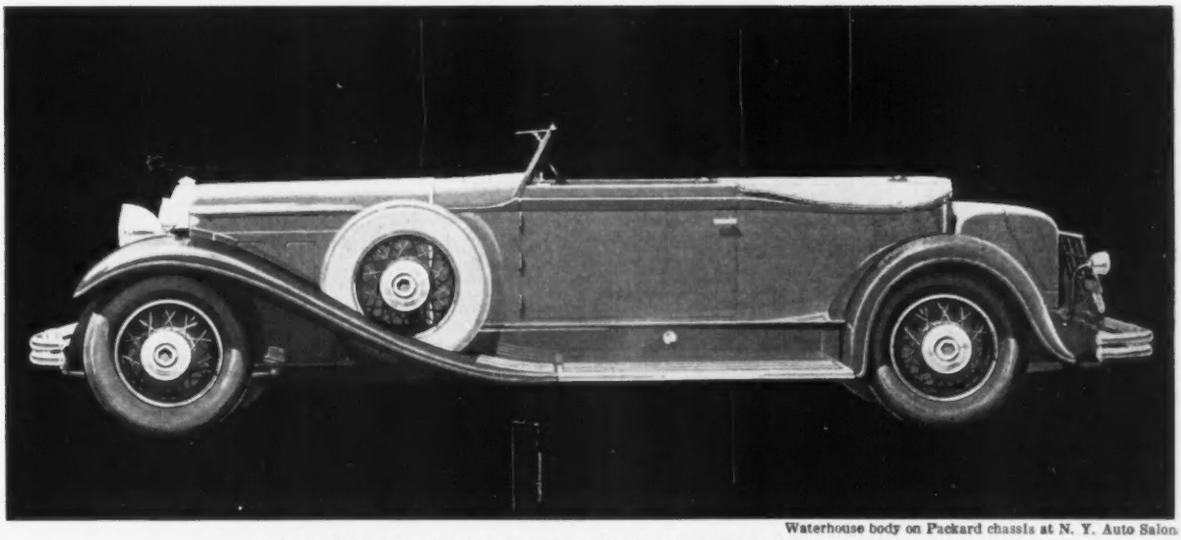
SUPERIMPOSED diagram of paths of points of mechanism shown in preceding figure

the figure. Thus, in superimposed diagrams of motions of link mechanisms, locations of points in the superimposed diagram form a figure similar to the figure formed by the corresponding points on the link itself. Therefore when the location of point C'_1 of the rod end C, corresponding to position A_1 of point A, has been found by the template method, the location of any other point E is determined by making the triangles $A_1C'_1E'_1$ and $A_oE_oC_o$ similar. Should the third point lie on the line A_oC_o, such as point D_o, it is merely necessary to divide the line $A_1C'_1$ into parts proportional to A_oD_o and D_oC_o, as shown in the figure.

The application of the template method and the theorem of images to plotting point paths of link mechanisms is illustrated in Fig. 6. Let the motion of point K, the middle of link CD be required. The superimposed diagrams are shown in Fig. 7. The successive operations are:

1. Draw the path of crank pin A to the scale required, and establish the twelve reference locations 0 to 11.
2. Plot the path $B'B'$ parallel to BB and mark the direction of shift B_oA_o for B.
3. Prepare a template of radius B_oA_o and find the locations 0-11 on $B'B'$.
4. Drawing triangles on $A'B'$ similar to ABC, find the locations of points of path $C'C'$.
5. Having found path $C'C'$ and the locations 0-11 of end C of link CD, draw path $D'D'$ parallel to DD and establish the direction of shift D_oC_o for D.
6. Prepare a template of radius CD and find locations 0-11 on $D'D'$.
7. Find locations 0-11 of K by halving the respective lines $C'D'$ and plot the path $K'K'$.

It will be found useful prior to construction of the superimposed diagram to plot in small scale the motion of the mechanism by the common method as in Fig. 1. This is helpful in giving beforehand a conception of the shape and size of the diagrams.



Waterhouse body on Packard chassis at N. Y. Auto Salon

Streamlining tendencies of 1931 body design—sleek, fleet, unmarred lines distinguish this convertible Victoria, shown with top down

Consider the Production Man

By R. H. BEEBE

Superintendent, Equipment Division, Westinghouse Lamp Company

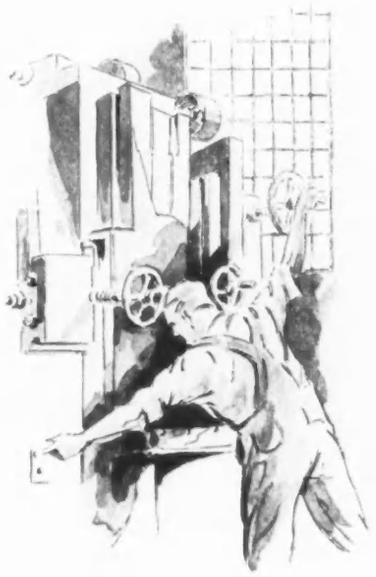
The ultimate customer for production machines is in the shop. Does this customer always get attention from the designer?

IN PRESENTING some of the factors demanding consideration in the design of production machinery as they affect the problems of the production executive, certain general rules, which are almost self-evident, can be laid down. These are what the production executive must observe: 1. Equipment arranged to facilitate the flow of material, and to eliminate unnecessary carrying of raw or partly finished material. 2. Adequate working space must be provided to avoid interference with machine operators, and to permit maintenance and repair work without undue interference with neighboring machines. 3. Adequate illumination is essential. 4. Machine processes involving excessive amounts of noise, heat, or odors should be segregated. These factors should be borne in mind in the design of the individual pieces of equipment. In the case of item 4, for example, an unsuitable design may force the breaking up of an otherwise perfect line of production and cause the loss of much time and money.

A principal item is the method by which the machine is driven. The individual motor drive is to be preferred, in spite of somewhat higher initial costs, owing to the elimination of overhead shafting, belts, and also clutches and belt-shifting devices. The problem of adequate lighting is made much more simple by the elimination of shafts and belts. The maintenance of belt and shaft drives is a considerable item, while the hazard of costly shutdowns because of failure of the main drive motor or the main drive must be counted against the cheaper first cost of the system. Lack of flexibility is also a serious objection to the shaft drive. It is not infrequent that we find such systems operating with a serious overload, because of additions which were not considered when the original installation was engineered.

The gearing in the machine should be arranged, so far as possible, to be adequately protected and yet readily accessible for repair or inspection. Where possible, helical gears should be used in order to reduce noise. In other cases, silent chains or resinoid gears may be used for the same reason. The bearings used should be ball or roller type where possible in order to permit higher speeds and reduce friction losses, as well as simplifying maintenance, since infrequent packings with grease replace the frequent oiling required on simple sleeve bearings. Any bearings or other working parts which require frequent oiling should if possible be arranged for automatic lubrication as this will save time for the attendant, or maintenance forces, and reduce the danger of trouble from neglect.

The speed at which a machine may be operated is an important factor in its worth as a productive piece of equipment. Anything which limits speed of operation must be studied closely to determine whether this limitation can be overcome. It is poor economy to sacrifice speed for lower first cost. A business that is adequately financed and capably managed cannot afford to keep equipment in service which is obsolete, slow in operation, or high in maintenance. Of these, the slow machine



is the most objectionable. Such devices not only use up space and require attention, which might equally well be devoted to a more modern and efficient device, but, by requiring additional units are wasteful of the floor space available. In many cases, additions to a factory could be avoided by junking obsolete equipment.

It may be thought that the above applied only to automatic machines, and that semi-automatic or non-automatic equipment cannot be considered on the same basis, due to the limitations of the operator. But there are limits to the speeds with which a man can work, and attempts to speed up production by requiring operators to work at the maximum speed are inadvisable, leading to dissatisfied labor, increased spoilage, and higher labor turnover. Speeding up the man is a policy that should be used only in an emergency.

The production executive, faced with the continual demand for higher rates of production per unit frequently finds that design of the machine limits the operator's ability to produce, rather than the latter limiting the rate of production. Poorly located controls, requiring awkward reaching, or unsuitable height from the floor to the work, will slow up the output of a possibly otherwise excellent device. The reaction of labor always is more favorable to improved and more efficient machinery than to a demand for speeding up existing machines. The provision of power-driven aids, such as hydraulic feed and speed mechanisms, power driven hoists, and other devices to save manual operation, are valuable measures in increasing output. It is very wasteful, both of the manufacturer's payroll, and the operator's energy, to pay men for lifting or carrying, or for supplying power to assist the operation of the machine. The function of the operator should be to guide and control the machine, and not to supply part of the power needed.

In connection with the matter of speed of the machines, and output per unit, the designer should make himself acquainted with every advance in tool steels, tungsten-carbide alloys, or super high-speed steels that permit high speeds and heavy cuts. Some cutting tools also permit smaller allowances for finishing castings, being unaffected by hard scale. But the use of such tools may frequently require new thinking on the part of the designer to produce a machine sturdy enough and sufficiently well powered and well adapted to stand the greater stresses and higher power demanded without being clumsy.

Many machines are of specialized types, or are built to order. However, parts will fail or wear out, and replacements will be needed. Simple designs in such machines, not involving complicated castings, easily machined, and not requiring hand finishing, are to be preferred. Ways that are ground and lapped, instead of hand scraped, for example, are preferable. It should be possible to remove any one part without removing five or six others to get at the part requiring attention. Bolts and nuts used to hold the machine together should be accessible without difficulty and should be standard commercial units not requiring special wrenches or screw drivers for tightening or removal, or special heat-treatment. The designer should remember the repair man's frequent remark: "I wish the so-and-so who designed this fool thing had to take it apart." Moreover, a few hours' loss of time on a production job can easily offset the saving in first cost of a "cheap" machine.

A further item of some importance is the finish used on a machine. This was formerly almost invariably black. Modern equipment, however, shows a fairly general use of lighter finishes, such as gray lacquer, light-colored paints, or aluminum paint. This is an improvement, for a variety of reasons. The light finish greatly simplifies the problem of adequate lighting. It also improves maintenance, as dirt or oil leakage show at once. This encourages cleanliness and better upkeep.

In conclusion, from the production standpoint, the machine must pay for itself. But in attempting to answer this question, when the production man comes to consider a new machine he does not stop at first cost, but rather he looks at the far more significant item of operating costs over some convenient unit of time.

Dials and Indicator Plates

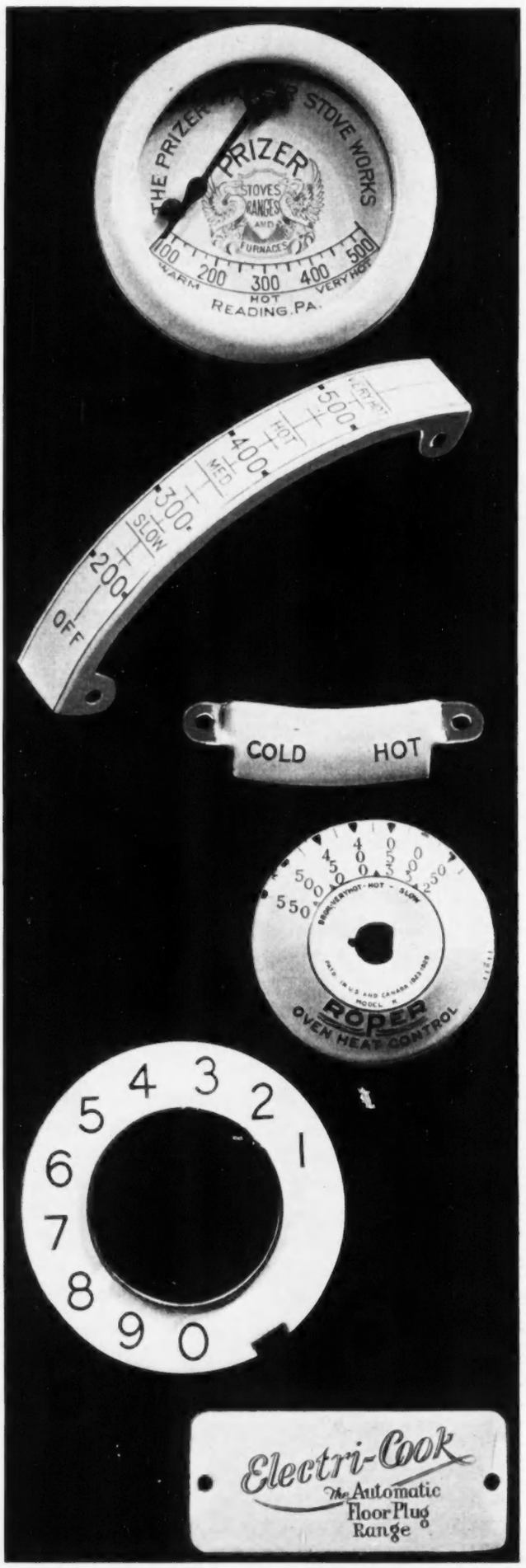
By HORACE R. WHITTIER

The Horace R. Whittier Company

FINE PRINTING, halftones, and line cuts can be permanently fired into vitreous enamels, thus making possible dials in any colors to match the product, and assuring protection of the dial design against heat, corrosion, oil, and chemicals

APPLICATION of vitreous enamel to dials, meters, and instruments is an industry quite apart from vitreous enameling as applied on a large scale to utensils, stoves, and other products where heat-resistance is the first consideration. It is not a process developed, however, in the sense that it is a newly discovered thing, but is the application of an ancient art to the requirements of the machine age. "Enameling" as a decorative medium on metal was considered as an "art" rather than an industry. It was developed fully 2,500 years ago and for many centuries was used only for jewelry ornamentation. Workers in enamel were skilled artists who belonged in the class with goldsmiths, and it was not until after the middle of the last century that the raw material of their art—vitreous enamel—was used industrially as a coating for utensils to resist heat and chemicals.

Meters, oven thermometers, thermostats for electric appliances, and many other modern devices required indicating dials that would be attractive and would withstand without deterioration the action of heat, acids, oils, and alkalies. Vitreous enamels were ideal to withstand all of these corroding agents, and had the added attraction that they could be produced in any color or combination of colors and designs. However, the old methods of lettering and decoration by the hands of artists were impractical for modern production, and some means of accomplishing this work economically had to be developed.



Vitreous enamel is a glassy material fused on a base of steel or copper, and as such gives an ideal surface to resist corrosion and climatic conditions, without discoloration, on meter dials and slot machine plates, and also high heat conditions on dials and plates for electrical appliances or stoves. For such application as telephone dials it serves the double purpose of wear resistance and corrosion resistance. But until modern methods of control of the mixture and of the baking temperatures were brought into the industry, vitreous enamels were often likely to be fragile and to crack and chip in service. It is now definitely established that with proper production methods and with suitable base metals vitreous enamel surfaces will withstand considerable shock without cracking. If an open-pore iron with a coefficient of expansion approximately equal to that of the enamel is used for the base metal, parts can be riveted to the enameled surfaces without breakage of the surface.

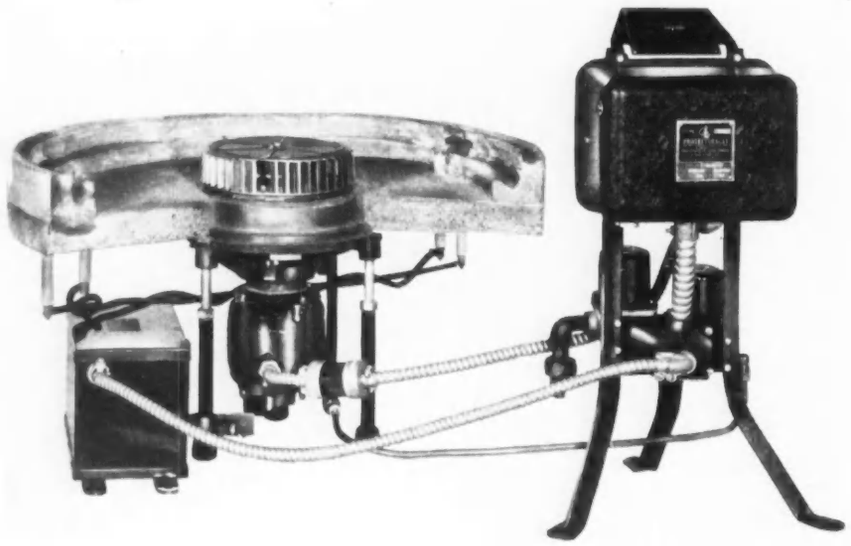
Dials made on copper are apt to be fragile because of the high coefficient of expansion of that metal, but where it is desirable to use copper to form intricate parts the metal should be as thin as possible. It can be stiffened by bowing, or by backing with a special coat of enamel. Dials and parts subject to severe service have as a base metal a grade of uniform iron called vitreous enameling sheet steel. A coat of blue cobalt enamel is first baked on at a temperature of about 1,600 deg. F., over which two coats of white enamel are baked successively. These finish coats give a clear white color that is adherent and will not discolor. The blue coat acts as a bond between the metal and the white enamel. It can be omitted where the base metal is copper, and this is one reason why copper is frequently used, in spite of its high expansion rate. On dial work where there are likely to be accurate holes or slots, spraying of the enamel is not done, but a fairly coarse enamel powder is sifted on the plates just before putting into the furnace. This material fuses evenly over the dial without flowing over the edges of the metal or into the holes. Needless to say an absolutely clean surface is required on the base metal before enameling. Iridescence, scumming, and off-color effects are avoided by heat and furnace atmosphere control.

Printing is the "fine art" of dial making, and is distinct from the stenciling ordinarily done on larger enameled signs. It is a transfer process done with oxide "inks," which are then baked into the enamel surface.

The ink is put on the engraved steel die and then rubbed or scraped off as in banknote engraving. The die is then put into a press where the design is transferred to a gelatine surface, from which it is transferred to the enamel surface. Since the gelatine surface is flat, allowance is made in the lettering or design for transference to a curved or formed dial surface. Until the recent application of this offset process to dial printing all printing on curved surfaces had to be done with decalcomania. The "inks" are metal oxides selected for firing qualities, permanence, and brilliancy. They are largely imported from France, and are expensive. The dials are dried before putting into the furnace to prevent running and smearing of the ink. Since all of these metal oxides have different firing temperatures it is necessary to bake each color separately, starting with the one with the highest firing temperature, in order not to overburn those with the lower firing points. This is an important point for the designer to remember if cost of the dial is to be a consideration. By this offset process of printing, dials can be produced with exceedingly accurate calibrations. Any design, including halftone illustrations, can be transferred and any color can be used. In calling for a dial design the designer should bear in mind, however, that a steel die must be engraved for the process and a separate printing and baking is required for each color. If large quantities of any one design are to be required the unit cost of the die is small, but if few are required the design should be simple.

THE number of heavy enamel coats put on fine dials assures perfect electric insulation, which is a distinct advantage in indicators for certain instruments. The field of application of vitreous enamel dials and plates is very wide, including such applications as oven control dials; thermometer and tachometer faces; gas, electric, and water meter faces; clock faces; heat indicators; electrical appliance plates; telephone dials; scale dials; slot machine plates; and nameplates for chemical machinery. The making of these dials is a highly specialized industry and product designers can obtain most economical results in dial appearance and service by cooperation with the makers, rather than in attempting to adhere rigidly to designs made without full consideration of the production problems involved. This is especially true in the selection of colors, since the metal oxide coloring materials have different service characteristics, and lettering to meet a given condition can sometimes be done in one color better than in others.

FEWER

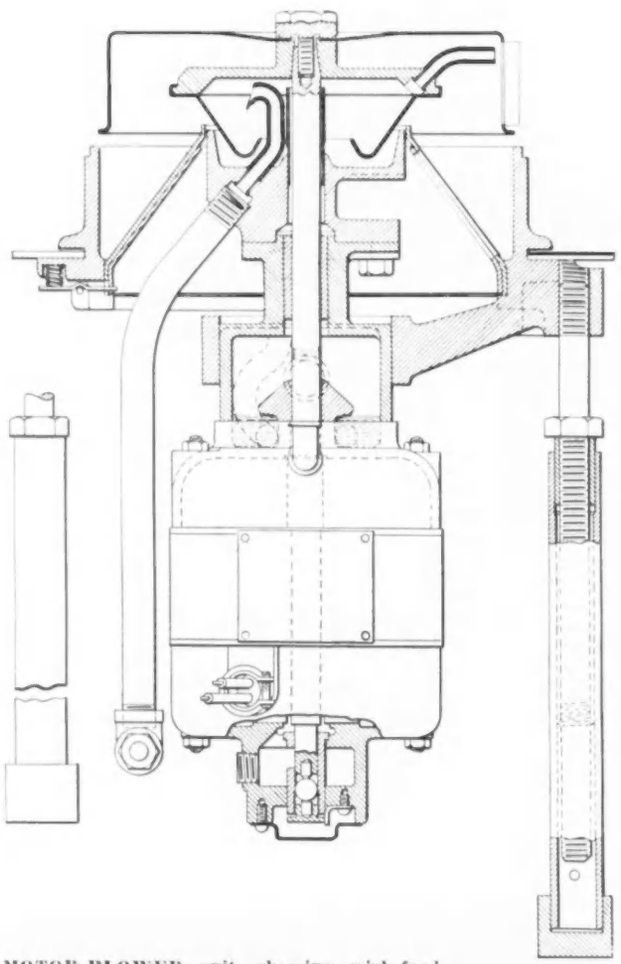


TIMKEN OIL BURNER, showing the two major units and the transformer for electric ignition. A portion of the hearth is cut away to reveal other parts

Simplification lowers the cost, Improves performance, Reduces service problems In this Oil Burner

SIMPLICITY in design, with a view to reducing manufacturing cost and to minimize the possibility of trouble in service, while at the same time improving performance, are the primary objectives achieved in the Timken rotary oil burner. The advance made toward these ends is evident from a comparison of the number of parts, number of wearing surfaces, and total weight of the present burner with those of the two preceding designs now obsolete. The first Timken burner had 641 parts, and weighed 320 lb. Its successor contained 214 parts and weighed 150 lb. In the present burner the parts total 118 and the weight is approximately 80 lb. complete with electric ignition system. The first model had 23 wearing and bearing surfaces and the second nine. In the present burner there are only three; namely, an upper and a lower motor bearing, and a ball thrust bearing to support the weight of the rotating parts.

The Timken burner is inherently silent in operation. Excellent heat transfer is obtained, as the burner unit proper is placed inside of the ash pit of the boiler and distributes the air and oil to the periphery of a special hearth, where combustion takes place directly adjacent to the furnace wall. Construction of the hearth is shown in an accompanying illustration. Its shape is varied to fit the particular furnace to which the burner is to be applied, special preformed refractory segments being installed around the periphery of the hearth upon a heavy refractory hearth bed.

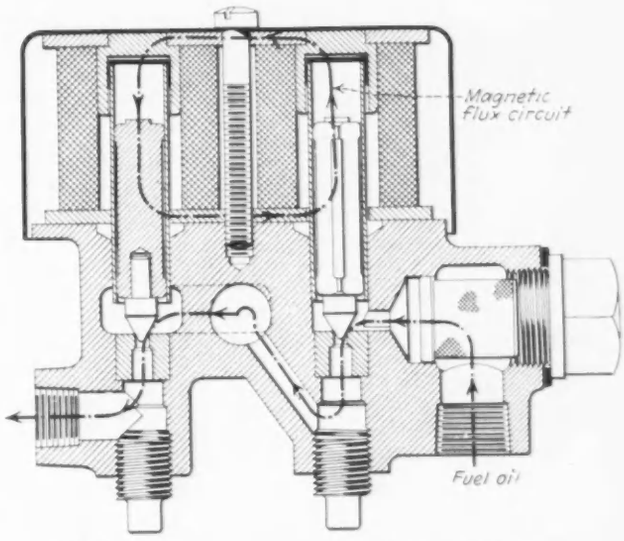


MOTOR-BLOWER unit, showing wick-feed lubricating system for motor, main supporting frame, air shutter, fuel distributor, and blower rotor

PARTS—LESS TROUBLE

By MILTON A. POWERS

Chief Engineer, The Timken-Detroit Company



MAGNETIC oil valve assembly. The arrows show the path of oil flow and also the magnetic flux circuit through both plungers. A manual regulating valve is placed in the passage between the other two valves

Either gas or electric ignition is provided. The latter, although slightly more expensive in first cost, eliminates the necessity for a constantly burning gas pilot light, and reduces operating cost.

Aside from the control accessories such as the room thermostat, the stack switch and constant-level float chamber at the oil storage tank outlet, the burner installation consists of two major units: the burner assembly and the control stand. In the former, a gray iron frame casting resting upon three legs, which are adjustable for length and for leveling and have rubber feet, supports the motor, blower and fuel distributor units. All moving parts of the burner assembly are easily removable for examination or repair simply by taking off the fan and distributor, loosening two screws holding the motor yoke in place, and disconnecting the oil and electric lines from the assembly.

The vertical split-phase 1/20-hp. motor has a single ball thrust bearing resting against an adjustable hardened plug at the lower end of the shaft. The motor is built to Timken design by The Robbins & Myers Company. It is supported in a split sleeve or yoke mounting designed to facilitate removing and readily allow vertical adjustments at the time of installation to establish the proper oil distribution level. The cylindrical extension of the upper motor bracket includes a wool-packed oil reservoir from which a wick feeds oil to the bearing above. Any oil seeping back from this bearing drops into the oil reservoir, precluding oil leakage onto the armature. Oil for the lower bearing is likewise supplied from a waste-packed reservoir. The motor, which turns at 1,750 r.p.m. with an average input of approximately 50 watts, does not require new lubricant more often than once a year.

AS SHOWN in an accompanying section, the motor shaft extends up through a fixed iron casting to which the oil feed pipe is attached, and carries on its tapered end a rotating distributor cup against which the fan wheel is clamped. When the burner is in operation, oil flows up the supply pipe through the overhanging discharge tube and drops into a pressed-steel cadmium-plated shell forming the lower half of the distributor. Oil flowing into this rotating conical shell, is divided evenly among the four tubes at the periphery, and is discharged horizontally by centrifugal force. The liquid fuel, issuing from the distributor head in a thin, even layer of spray, strikes the hot refractory hearth ring at the proper level for vaporization. A drum-shaped stamping of 18-8 stainless steel forms the one-piece fan wheel, the vanes being stamped out of the rim. This fan delivers a regulated supply of air to the hearth ring where the air mixes with the vaporized oil, which burns with a bluish yellow flame.

INASMUCH as the Timken oil burner operates efficiently over a wide range of capacity, it is possible to meet all needs with a single unit. The burner will handle from about one to about eight gallons of fuel per hour. As no one fan would be capable of delivering air throughout the required range of supply, a number of fans having different blade shapes and sizes, but all stamped from the same blank are available.

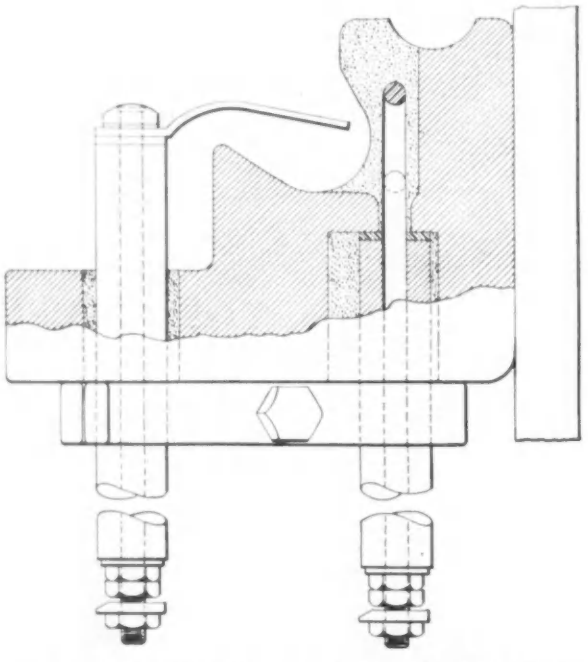
Fitting into the main frame just below the blower, and controlling its air supply, is a pair of cadmium-plated conical stampings nested one inside of the other. The outer stamping is fixed, but the inner one, held against the other by spring pressure, can be rotated to expose the desired port area, and is then locked to maintain the exact air supply required for efficient combustion.

When electric ignition is employed, two special igniter assemblies are installed on opposite sides of the hearth, each assembly having a pair of Isolantite-covered electrodes extending downward through the hearth member. A stainless steel finger forming part of the inner electrode projects across the groove in the hearth segment toward the vertical wall against which the oil impinges. The outer electrode consists of a special Carborundum insert molded into the segment wall. Current is supplied

by a special heavy-capacity transformer, and produces an arc-like spark at each of the igniter gaps, which are connected in series. The intense heat at the oil wetted carborundum surface causes prompt ignition under all operating conditions. The electrodes are located below the high temperature zone of combustion, and the stainless steel and carborundum electrodes are well adapted to withstand the temperature and oxidizing conditions encountered.

When gas is employed for ignition instead of electricity, a separate solenoid-operated by-pass valve supplies additional gas to the continuously burning standby pilot, giving a greatly enlarged gas flame during the starting cycle, thereby assuring prompt and certain ignition of the fuel.

LOCATED outside the furnace is the control stand. Its three-legged frame is of angle iron spot welded together. Attached to this frame is the Minneapolis-Honeywell Protectorelay which controls the motor, fuel valves, and ignition system in response to the demand



IGNITER assembly in part section. The inner electrode has a stainless steel blade welded to its upper end. The spark jumps the gap to the Carborundum cement in which the second electrode is embedded. Insulators are of Isolantite

of the room thermostat, and subject to the supervision of the safety controls.

Also mounted on the control stand is a magnetically-operated unit incorporating two solenoid oil valves placed in series with a plug-type metal-gauze filter at the inlet and a manually adjusted regulating valve between them, as shown in an accompanying sectional view. The two 55-volt solenoid coils are connected in series and are so placed that they form a single magnetic circuit, the flux flowing through both plungers. When the motor circuit is closed, the solenoid coils, which are connected in parallel with the motor, are energized and the plungers lift, opening the two fuel valves. Fuel then flows to the burner under a fixed head through the previously adjusted regulating valve. The instant that the motor circuit is broken, the plungers drop by gravity and cut off the fuel supply. A single magnetic valve could be used, but, despite extreme care in filtering the fuel, a single valve occasionally may allow leakage. By using two valves in series, however, the chances of both failing to close completely at any time is negligible, and no other protective means on the oil line is required.

Control of the Timken burner is effected by a Protectorelay unit comprising two small relays, a transformer to provide low voltage for the room thermostat circuit, and a thermal safety switch, all mounted on a Bakelite panel with cast aluminum base. Functioning is as follows: When the room thermostat calls for heat, it closes two contacts, energizing one relay, thereby closing the motor and ignition circuits and opening the oil valves. At the same time a circuit through a heating element on the thermal switch is completed, starting the timing period during which normal combustion must be established if the burner is not to be automatically shut down by the thermal switch. If combustion starts promptly, the rising furnace temperature closes contact on a bimetallic Pyrostat, installed in the stack, actuating the second relay and opening the first relay. This cuts off ignition and opens the heating element circuit of the safety switch, thereby permitting normal operation to ensue.

In case the fuel fails to ignite, the first relay remains closed and the thermal safety switch continues heating until after two minutes time, the running circuit is opened causing a shut-down. If this occurs, it is necessary to press a reset button manually to effect a new start.

When, as a result of normal operation, the room temperature rises and the thermostat opens, the second relay is tripped and the burner shuts down. The stack Pyrostat then must establish its cold contact before a new start can be made. In the event of flame failure during operation, the stack temperature falls, opening the Pyrostat's hot contact, thereby de-energizing the relay and stopping the motor. After sufficient time has elapsed to establish the Pyrostat cold contact (the delay allowing the firebox to clear of any residual gases) the burner goes through a new starting cycle. If proper combustion is established, the burner will continue normally without further attention. If combustion is not established, however, the burner shuts down and requires manual resetting. The circuit is such that if power on the service line fails, even momentarily, the control automatically recycles when service is restored. This arrangement provides the safety features required by the Underwriters' Laboratories.

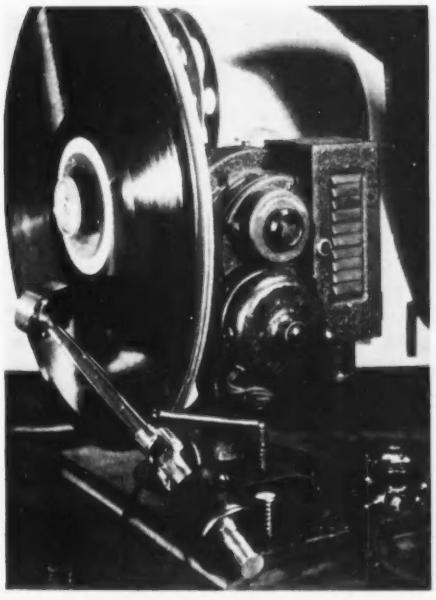
BLACK enamel has proved a satisfactory finish on parts of the burner and control stand not otherwise covered. Cadmium coating protects the distributor, air shutter, threaded leg adjustments, and other small parts. The fan wheel being of stainless steel, requires no finish. The upper portions of the burner frame are given a coat of heat-resisting aluminum paint. Particular attention has been given to making the control stand of pleasing design. It is provided at the top with an attractive nameplate.

COMMENT AND SUGGESTION

Compactness in a Home "Talkie" Machine

DESIGN ideas of unusual cleverness are incorporated in the "Animatophone," combined projector and phonograph for "talkie" work. The turntable is mounted vertically directly on the film projector, instead of horizontally, in order to gain compactness. The turntable is an integral part of the projection mechanism and is driven directly by the same motor, thus differing from the more usual "hook-up" type employing an auxiliary, shaft-connected turntable and silent projector with its accompanying difficulties of operation. It is, moreover, planned so that the phonograph can be sold alone, and the turntable added later, if desired.

The use of a heavy-type synchronous motor for turntable use is not necessary, there being an unusual governing device, incorporating an automatic air governor. This unit maintains uniformity of speed at either 33⅓ or 78 r.p.m. by utilizing a stream of air created by the motor speed. This stream is impinged on a small vane which automatically makes and breaks the current supply to the motor, depending on the force of the air stream. A small indicator dial is set for the desired speed—for either the record of the 33⅓-r.p.m. "talkie" type or the usual 78-r.p.m. phonograph type.



The counterbalancing weight beyond the universal joint of the tone arm is so constructed that it permits the needle of the arm to retain the center of the groove, thus minimizing record wear. Tone-arm pressure, instead of depending on the weight of the arm, is governed by spring tension.

Provision against film damage—highly important with synchronized films—is incorporated in a film trip which cuts off power and light automatically if the film fails to track properly. An adjustable shuttle provides steadiness and quietness of operation.

■

STOP... LOOK... LISTEN...

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. . . OVER-SPECIALIZATION . . .

SPECIALIZATION enables concentration on definite problems and results in greater accomplishments than are otherwise possible. But too great specialization frequently leads to an unbalanced condition because of the failure to see more than one phase of a problem. Designers may easily specialize on certain types of mechanisms and fail to see where other and perhaps simpler types would be an improvement.

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. . . ACRES OF DIAMONDS . . .

SADI CARNOT'S famous brainchild, his thirty-page dissertation on the maximum possible efficiency of the perfect heat engine, received no attention for many years. This was because Sadi's friends recognized him as an artist and a poet, and not as a scientist. They did not give him sufficient credit for his ability to reason clearly. It pays to scrutinize closely the work of the logical thinker, be he shopman, draftsman, or cub engineer. He might hand you a diamond that looks to you like glass.

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. . . A LONG TIME BETWEEN . . .

THE Baltimore and Ohio railroad has been receiving considerable publicity on its all-welded hopper car. Yet as long ago as 1911 the American Car and Foundry Company designed and built a spot-welded car which was subsequently used for hauling ore. In spite of the hard service it was put in, last reports were that it is still doing duty. When it comes to imbibing at the springs of progress, it surely seems to be a long time between drinks as far as the railroads are concerned.

■

Shooting at Weight Reduction

By John F. Hardecker
Chief Draftsman, Naval Aircraft Factory

DESPITE the growing list of general production organizations that have profited by eliminating unnecessary weight in their products, there is a far greater class which, although admitting the desirability, hesitate at what they believe will involve a revolutionary upheaval in materials and methods. There is a disposition to see only the specialized details of extreme weight saving, design such as are necessary in aircraft, and to stress the impracticability of such details in selling specialized products. In other words, there is general failure to penetrate the fog of detail for a glimpse of the principle.

Suppose that a machine tool weighing a thousand pounds is to be redesigned and that weight saving is regarded as desirable. The first step is to fix definitely the total weight saving desired, say 250 pounds. In the next step a reasonable weight "breakdown" of the existing machine is secured by actually weighing its parts. Next it is desirable to ascertain in which parts the weight will not change for obvious production reasons. In general, such standard parts as bolts and nuts, as well as intricate castings and forgings for which the patterns or dies should remain as they are for economic reasons, are included under this head. Possible exceptions might include the introduction of lightening holes in a pattern or a reduction in the number of bolts. If these unchanged parts weigh 300 lb. the weight saving de-

sired must be made in original parts totaling 700 lb. in weight, and, to realize the objective set, these parts must have their total weight reduced by 250 lb. or 36 per cent. Adjustments and re-allocations of weight will have to be made, of course, as the design progresses, for it will be easier to save a greater percentage of weight on some parts than on others. A check of estimated weights as parts are redesigned will disclose the trend of the total weight figure, and will point out the need for concentrated engineering attention on parts running greatly overweight in comparison to the allowed weight.

Such a procedure is quite simple. The only really difficult task is to overcome the mental hazard of trying merely to save "as much weight as possible," and actually to set up a logical weight as a target to shoot at.

■

Standardizing Design Calculations

By Victor Tatarinoff
Mechanical Engineer, Pilsen, Czechoslovakia

A FACTORY constructing lifting gears and davits for steamships had a fluent staff of designers in the drawing office. The work to be produced was very intensive and each change in personnel caused considerable difficulty. Observation showed that each designer used his own special method of calculating for similar constructional parts without comparison with previous practice. Thus, the same problems were solved by a variety of different methods, resulting in difficulties both in checking and in future design. In fact, designers often had difficulty in checking their own calculations.

The result of the investigation was the requirement that designers submit their completed calculations with the drawing, and that the shortest and most accurate methods of calculation be standardized for certain definite types of work. Calculations are now printed as standard sheets, being revised in exactly the same manner as engineering drawings.

Auxiliary information essential in this sort of an organization is : (1) General engineering weights and measures tables, (2) a table of specific gravities and mechanical properties of materials, (3) Fundamental formulas, and a suitable set of graphics for calculating the strength of different constructional parts, (4) A set of specimen and reference sheets for air, steam, gas, and hydraulic calculations, (5) Special tables showing frequent errors and how they may be avoided.

It is desirable to print the specimen and calculation sheets on tracing paper, thus making it possible to show complete calculations on blueprints. Although this system introduces a certain amount of time loss in preparing the calculations for tracing and printing, it will prove a great facility in checking and in eliminating errors.

■

. . . OIL! . . .

WHY worry about oil or grease? "Lubrication is the job of the maintenance man," somebody says. But it might just as well be said that the designer shouldn't worry about production of the machine, either. If the machine or other product has moving parts, one of the first questions the designer should ask himself is *how* and *with what* are the bearings to be lubricated. He must answer those questions in his design before it ever goes to the production or maintenance man.

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. . . ON THE FIRING LINE . . .

"TAKE the laboratory to the field, if the field cannot be placed under a bell jar in the laboratory," says L. K. Wright in discussing cadmium and zinc coating tests in *American Machinist*. That's good advice, and applies to many things besides protective coatings. The laboratory engineer, when he goes into the field, often will do well to lasso the chief engineer and haul him along! There "ain't no sech animile" as too much engineering contact with conditions on the spots where products are used.

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. . . ANOTHER NEW METAL . . .

A METAL that we are going to hear more about very soon is indium. It occurs in such small quantities that it is classed as a rare metal, but small amounts of a metal go great distances for plating purposes, and indium looks like a good bet for plating. It is lustrous white in color, very ductile, and does not tarnish in the air. So far it is not a commercial product, but research moves rapidly these days, and we ought to have it soon.

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. . . WELDED COPPER . . .

WHERE copper is selected as the material for large tanks or vessels in place of steel, the specification of welded joints for such a vessel puts a real problem up to the shop on account of the high heat conductivity of copper. With a copper-silicon-manganese alloy, however, the heat conductivity is comparable with that of steel, as is the strength, making the material one remarkably easy to weld. Tanks of this alloy are now being regularly fabricated and applied to all sorts of uses where corrosion resistance is wanted.

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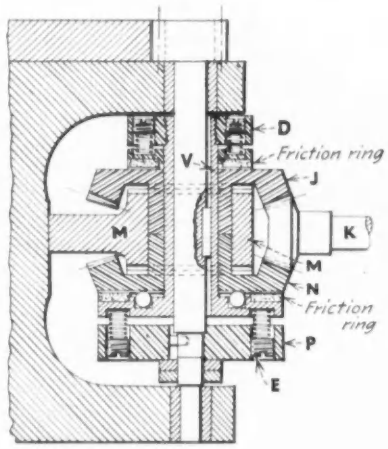
. . . ORGANS AND AIRPLANES . . .

ADAPTABILITY is one of the most desirable qualities in a designer. A well-known organ builder chided his son for fooling around with airplanes. But when the organ business petered out he utilized some of the "innards" of the organ and designed around them a training machine for embryo pilots that saves time, money, and hospital expenses.

Automatic Overload-Reverse Mechanism

By James R. Cornelius
Coventry, England

POSITIVE drives on some machines endanger either the pieces to be fed, the tools, or intermediate parts of the machine. The usual slipping clutch is



not always satisfactory, because the driving force must usually be either slightly relieved or reversed entirely before the operation can continue. The design of drive here described is such that when the driven member is overloaded, either suddenly or gradually, the drive mechanism automatically reverses the direction of rotation of the driven part for a predetermined short period of time, and then the rotation reverses again to its normal direction. It may be used for driving feed hoppers, delicate saws, and similar applications.

In the sketch shown, K is the driving spindle, and transmits its motion through the bevel pinion to the two bevel gears J and N. These latter run free on the hollow spindle V and are held in a fixed longitudinal position by the bearing M. A friction ring is

fastened as shown at each end of the hollow spindle, and a plate D is screwed fast to the upper end. The hollow spindle is free to slide but not to rotate on the central shaft. In addition to the friction rings the lower end of the hollow spindle is fitted with four or more steel balls located in blind holes of uniform depth. These balls protrude from the holes such a distance that when they rest in radial grooves cut in the face of the wheel N, the lower friction ring fully engages with the driving face of the bevel gear. However, should the balls roll out of the radial grooves, the friction ring would come out of contact with the driving face of the bevel gear. In normal driving, the springs located in the end plate P exert sufficient pressure to keep the balls in the radial groove. At the upper end of the sleeve, the plate D is also fitted with springs which bear against the plate carrying the smaller friction ring. By means of the screws, the distance of the plate from the face of the wheel J can be regulated so that the friction ring is just free from the face of the wheel when the balls are located in the radial slots of the wheel N. In this position, any movement from the spindle K will drive the two bevel gears in opposite directions and the lower bevel gear N will, through the friction ring, drive the central shaft.

As soon as the rotation of the central shaft meets with excessive resistance, the wheel N, being positively driven, moves relative to the spindle on which it is mounted, causing the balls to leave the slot in the face of the wheel. This moves the sleeve V downward and separates the friction ring from the surface of the wheel N. The same action causes the upper friction ring to bear against the wheel J which is rotating in the opposite direction. Thus the rotation of the hollow spindle and the central shaft is reversed, and this reverse rotation continues until the balls come into line with the radial slots in the wheel N. When this occurs the sleeve immediately drops back to its normal position by the action of the lower set of springs, the lower friction ring coming in contact with the face of the bevel gear N, and the original direction of rotation is resumed. The driving torque normally transmitted can be adjusted within the limits of the design by means of the screw E.

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Molded Plastics for Parts

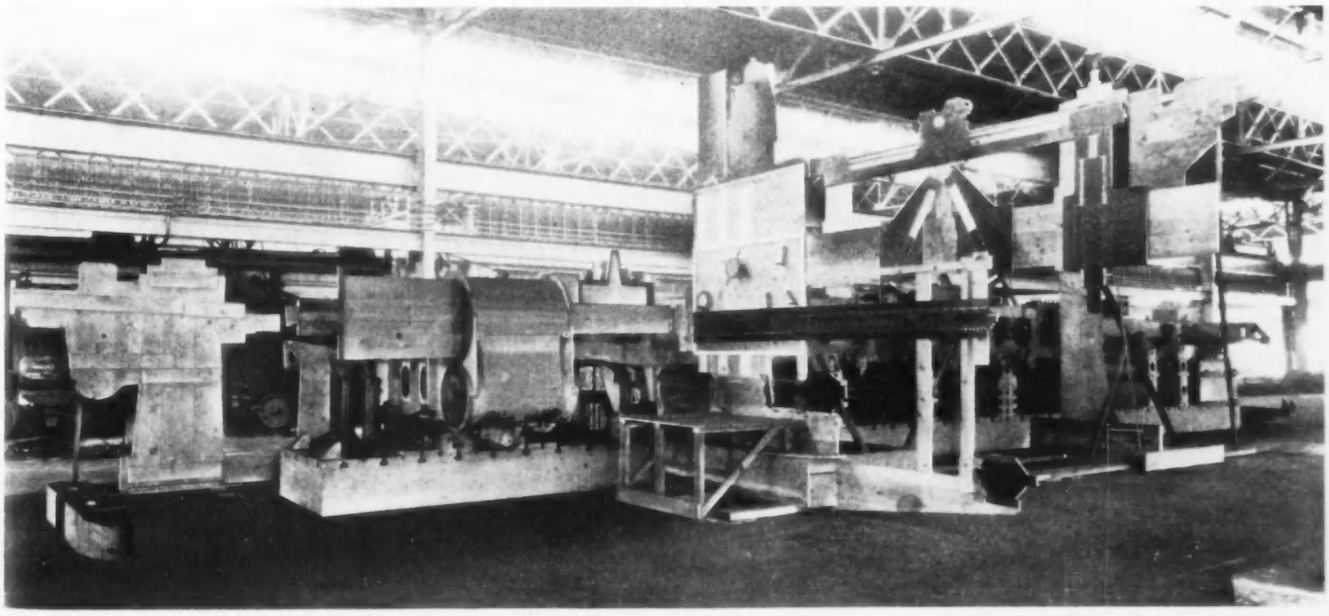
"PLASTICS" are coming into their own with the designing engineer. There was a time not long ago when the engineer was inclined to shunt aside all basic information about "plastics." Molding compounds were things for the chemist to worry about, and possibly there was some reason for this when one considers the formidable names that were handed out for digestion. "Phenol - formaldehyde," "glycerol-phthalic anlydride," and other names are fortunately now being left to the laboratory, and have been replaced in the trade by easier trade names. In the meantime the synthetic plastics are replacing metals for many parts in products to such an extent that no engineer can afford not to familiarize himself with the various types and their uses.

Visualizing Design on Expensive Castings

SMALL scale drawings of large machines are far from satisfactory in many ways. The average mind refuses to multiply or divide accurately enough to visualize the completed machine correctly from a small scale layout. For this reason we have had full scale blackboards in many drafting rooms to enable the designer to see just how the machine will look when it is built.

The illustration shows a method of visualizing a problem not only to assure proper proportions in the design, but also to make certain that machining operations are possible. A similar idea is used in airplane plants when designing a new model, and is called a "mock-up." The wooden skeleton model shown here is that of a large locomotive bed plate, and the wooden skeleton outlines are those of the machines planned to machine the various surfaces.

The locomotive bed plate is a single casting that includes both side frames, cylinders, valve chambers and necessary cross members. As shown, the frame is upside down so as to bring the openings in the pedestal jaws on top. The frame rests on supports and is to be worked on by three tools, a planer at the rear, a shaper at the side and a boring machine at the front. Each of these machines are represented in skeleton form with the tool heads, control levers and motors indicated. This was the method used by the Baldwin Locomotive Works in determining the machining possibilities.



PRODUCT ENGINEERING

Editor: KENNETH H. CONDIT

January, 1931

. . . "The rate at which money circulates depends more on the work of research laboratories than upon banking institutions. There is nothing to be feared from the mechanical age if new products are developed continually" . . .

—ROGER BABSON.

Volume 2, Number 1

WITH this number *Product Engineering* begins its second volume. Founded one year ago by the McGraw-Hill Publishing Company to serve the product development engineer it continues with the same staff and the same name. The editorial staff is made up of: Kenneth H. Condit, editor; George S. Brady, managing editor; Fred H. Colvin, consulting editor and George F. Nordenholt, Herbert Chase, Frank J. Oliver, Jr., H. R. LeGrand, E. J. Tangerman, and C. G. Smith.

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Time for the Show!

"IF YOU have two loaves of bread, sell one and buy a flower." That is the wisdom of a Greek philosopher at the time when an art was in the making that has come down to us unrivalled through a period of twenty-five centuries. That was the beginning of the age of sculpture and architecture—This is the beginning of the age of machines. The similarity is, that like the ancient Greek the new generation of machine designers has had enough of the "Babylonian brick" period when metal products were utilitarian only, and is on the threshold of the recognition of the aesthetic values in mechanical parts.

It is seldom necessary to apply the formula literally. Appearance can usually be added to the product by small attentions to form and expert advice on finishes without any sacrifice of utilitarian value. But the importance of appearance as a sales feature of the product has become so well recognized already that some large manufacturers are having drawings and models made by artists first, and then asking the machine designers to work within the specifications. This applies to automobiles, metal furniture, electric motors, and household machines. It involves attention to form, color, and finishes from the standpoint of the buyer and user of the product.

Actually, the trend means that the designer has more influence on the control of our social life than he usually appreciates. With his machine design he is making this machine age. But he must appreciate the artist's viewpoint that the public is not interested in sober and dull mechanics, but wants its machines dressed up. In other words, appearance of the product has become one of the major factors in design.

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What Is the Engineering Charge?

BUILDERS of special machinery, and of special-purpose equipment, continually bemoan their fate, that they seem to be doomed in the grind of competition to be satisfied with a moderate profit on the machine of their design while the production plant frequently reaps profits over a long period with the machine. It would seem that here is one place where the chief engineer must assert himself and sell his engineering in the general interests of his company.

Not long ago an executive of a large automobile plant called in the chief engineer of a company well known as a builder of high-class and ingenious equipment. The executive put up to the engineer a definite requirement of accomplishment in a machine which he needed. It was a "sticker." The engineer spent his whole week-end at the hotel making sketches. Finally, a solution struck him—a very simple design that could be built cheaply. Next morning it was accepted in principle, and the machine builder, after a careful estimate of labor and shop costs, sent back a price of $3,000, which was also accepted.

But building the first machine was not so

simple, after all, as is usually the case. Complete engineering drawings had to be made that took time and worry. Many engineering knots in the shop had to be untied. The profit on the machine was ridiculously small, but it went out at the price and turned out to be a fine production tool.

Later, the executive met the chief engineer informally. Said the buyer: "Do you know that we spent $20,000 in trying to develop a method of doing that job before we called in your company?" In other words, the machine doctors—the chief engineer and his staff—asked nothing and got nothing for their company in payment for their trained experience and knowledge. The estimate for the machine called for so many hours of "labor" for engineering, with nothing for "knowledge." Probably a flat charge of $3,000 for engineering alone would have been more appropriate.

When will engineers and engineering plants—real ones that can put real ideas into metal—begin to sell their engineering knowledge instead of so many pounds of metal and so many hours of labor?

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What of Engineering Incentives?

SYSTEMS for compensating mechanics and foremen who discover new time- and labor-saving devices are common, as are also bonus plans for salesmen when they do a good stroke of business. But few are the instances where good hard coin, in excess of normal salary, has been paid to engineering employees for especially meritorious work. Even the patents which some designers secure in the hope of future rewards are denied to engineers, who are usually required to sign away their rights, in some cases for work done outside of their regular jobs.

Perhaps assurance of prompt and adequate salary increase for work involving initiative and originality should constitute a sufficient incentive, but there should be no procrastination in making a substantial recognition of such work. One case may be cited in which an engineer, who, through sheer cleverness in evolving a new design, saved his company a sum said to mount into seven figures, but is still waiting, after nearly a year, for a promised salary advance.

Certainly there should be incentives for original engineering work. A substantial cash payment may be made in some instances. Salary increases may suffice in others. But unless ability is recognized and rewarded, initiative is likely to be stifled, and the company really cheats itself.

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New Designs for Old

SOME interesting comments were brought out by the article in the December number of *Product Engineering* on a proposed rear-engine automobile. They range from suggestions for a bumper all the way around the car to adaptation of the design to tanks and tractors. Anyway, it seemed to indicate that engineers do not feel that the present-day automobile is the last word. Considering now the matter of trucks, it is interesting to speculate on what would happen in design improvement if all the chief truck designers in the country had to operate their trucks, load and unload them, for six months in the streets of New York or any other busy commercial city.

One of the big traffic problems in the narrow streets of cities in the Eastern States is the tying up of through traffic by trucks backed-up to the curb. There is no other way to load and unload them. Again, it is doubtful if the ordinary two and one-half ton truck ever averages loads of 4,000 pounds, yet the chassis alone will weigh up to 5,000 pounds and the body 3,000 pounds. In general four tons of dead load must be moved and stored in the streets in order to move two tons of pay load. And consider, also, the great added wear on roads and streets, not to speak of the added demolition effect when such a mass gets into a collision!

It will not be denied that our automotive industry is among the foremost in progressiveness, but as we smile today at the seriousness of the designers of thirty years ago over their crude designs, so will the next generation smile at us—only more so, because progress is moving faster now. And this does not apply just to automotive designs!

WHAT'S GOING ON—

The Month In Product Design

THE 10,000-KW. steam turbine for the new Delray station of the Detroit Edison Company will operate at a steam temperature of 1,000 deg. F., and a pressure of 400 lb. The high-temperature casing was made in one piece. Diaphragms holding the steam nozzles between stages are held in place by an inner lining or secondary casing having a horizontal joint. Corrugated piping bends connect the high- and low-pressure elements. The generator housing has a flat top provided with quick-opening doors used in case of failure of the air cooler. The generator itself will be excited by two direct-connected exciters instead of the one unit customary in this country. A Babcock & Wilcox superheater will supply the high-temperature steam to the unit, and will be separately fired with fuel oil.

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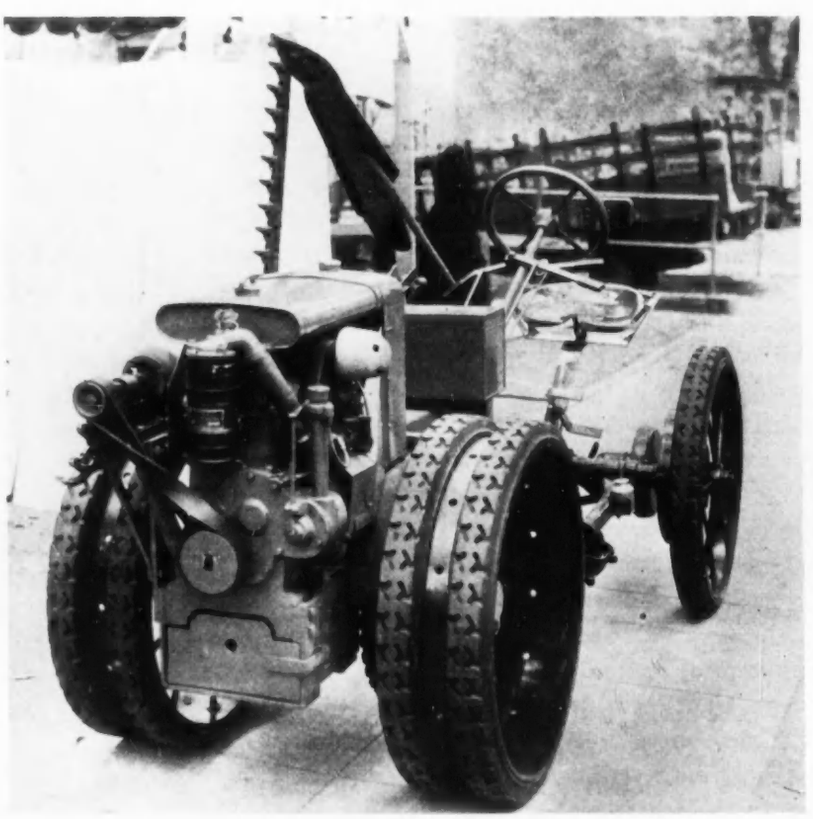
ULTRA-SIZE PLANERS now being manufactured by the G. A. Gray Company incorporate 407 ball and roller bearings of seven different types. Among the design features, according to *American Machinist* are four ways, two V's and two flats, three rows of leveling screws, one being at the center of the bed and accessible from the top, a steel camber beam attached to the top of the rail to insure straight cut as the head travels across the rail, support of each head on the cross rail on two hardened rollers mounted on ball bearings instead of having the load come on the upper gib, over-counterbalancing of all heads to take up lost motion at all times, automatic centering of supports for all cross rail screws and feed rods, complete interlocking control of all movements from either side of the planer and at the tool heads, and the use of electric motors to lock and unlock the rail at the housing.

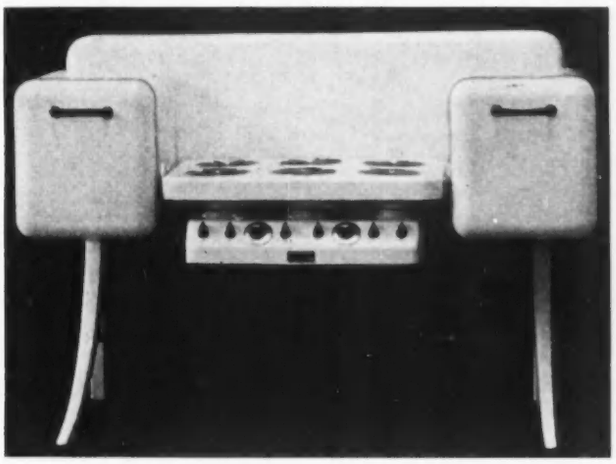
A Glance Over the Pages

1. *Why is manganese steel used for dipper lips on mine shovels? p. 2*
2. *When does the constant relationship between stress and strain cease? p. 11*
3. *What material is used in fabric welding dies? p. 18*
4. *How can full-size plots of link motions be avoided? p. 19*
5. *Why should the production man be considered in designing equipment? p. 22*
6. *How can copper replace iron in making vitreous enameled dials? p. 25*
7. *How is oil seepage handled in designing oil burners? p. 27*
8. *Who is the new president of the A.S.A. p. 38*
9. *What are current trends in aircraft design? p. 37*
10. *Do calculations for press and shrink fits vary for cast iron to steel and steel to steel fits? p. 47*

THE FLOATING PONTOON gate lifter for the new Welland Ship Canal is capable of a vertical lift of 500 tons. It is entirely self-contained except that it is not self propelling. While the craft is only 90 ft. in length, with a beam of 66 ft., the towers stand 72 ft. above the deck. Four screws for providing lifting power are each about 54 ft. long and 10 in. in diameter and are driven by separate electric motors. Controls for the four units are locked together to operate as a single hoist after the load has been properly equalized. A system of shifting water ballast is used, with electrically-driven centrifugal pumps to transfer water as required to prevent overbalancing of the pontoon during lifting operations. Power for all motors and electric controls is supplied by a main engine of 300 hp., direct-connected to the generator.



Centaur highway mower with Le Roi twin-cylinder motor, dry-plate twin-disk clutch, anti-friction bearings, dual clutch control, and front wheels designed for chains



Two-oven Electrochef Master, 68-in. wide, utilizing optional timer controls for either oven, six standard heating units, each with three heat speeds, and finished in chrome-plate and either white or green porcelain enamel.

SALIENT-POLE, synchronous motors to be started under load have usually been unable to develop the necessary starting and pull-in torque without incurring excessive current inrush or using an intermediate mechanical starting device. Westinghouse has developed a motor with starting and accelerating characteristics similar to a wound-rotor induction motor by replacing the ordinary cage-type damper winding in the pole heads with a phase-connected damper winding. The ends of this winding are brought out to slip rings, permitting the use of a variable external starting resistor similar to that used with wound-rotor induction motor. This resistor is automatically cut out, in steps, by the controller, and when synchronous speed is approached d.c. excitation is applied and the motor synchronized. This motor, unlike the synchronous-induction type, utilizes standard excitation voltages of 125 or 250 volts d.c. and requires low exciter capacity comparable to corresponding ratings of low torque design.

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AN ELECTRO TABLE manufactured by Altorfer Bros. Company combines practically all kitchen operations in one unit. Means are provided for mixing and preparation of foods and a double electric socket is located at the side. The unit operates an ironer and provides storage space for the devices supplied as standard equipment. It is 32 in. high, 30 in. wide.

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NEW BATTLE CRUISERS for the United States Navy utilize more welded construction than ever before. Welding is used for the attachment of fittings, locations where local strength rather than general structural strength is involved, all seams and butts of the superstructure deck, upper platforms, and deckhouses are welded complete. In addition, the entire piping system was built up by welding. High-strength aluminum alloys were adopted throughout the ship for divisional bulkheads, furniture, fittings, and similar parts. Cork insulation is also used extensively and is cemented directly to the structure.

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MOVING PICTURES in relief were forecast recently by Dr. Herbert E. Ives of the Bell Telephone Company. The necessity of having spectators wear special goggles or other devices to direct separate pictures to each eye must be eliminated, and the only available method is by altering the design of the screen. This problem has been solved by using the same general kind of pictures and ridged structures which have been worked out for making parallex panoramograms. In one method, the screen is built up of celluloid or glass rods so calculated as to reflect light directly back in the direction from which it comes. A large number of pictures are then thrown on the screen from a battery of lanterns standing side by side, the pictures projected having been made originally from a series of different points of view. Each of the pictures on the screen can be seen from only one direction, so that, with a large enough number of projectors, any observer sees a separate view with each eye, no matter what his position.

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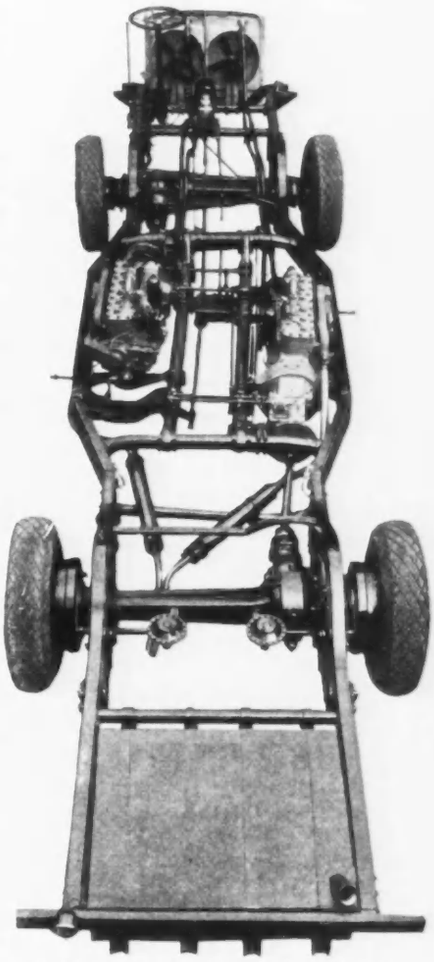
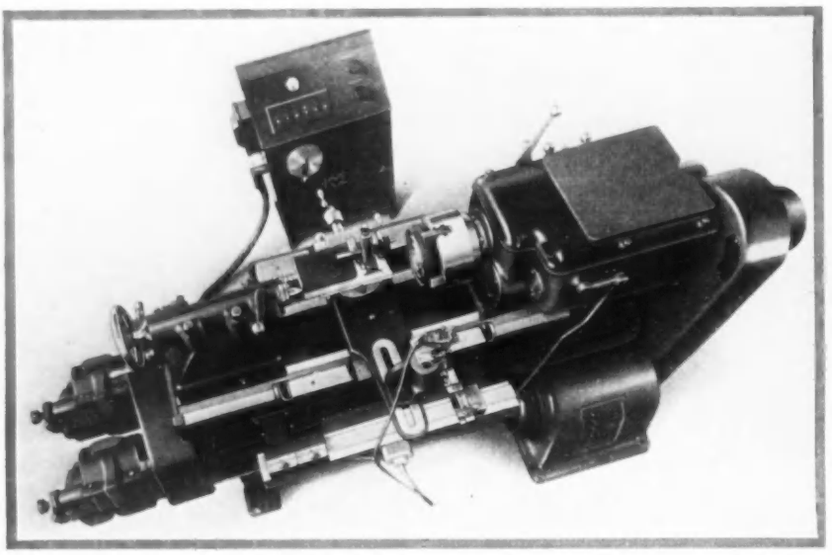
PORTABLE CLOTHES WASHERS made by the Kohler Company utilize an oscillating impeller with six blades, each ending in a pronounced shoulder or hump. When the impeller oscillates, the size and design of the blades gives the water a radial action, churning it with a backward lash around each vane. The tub is coated inside and out with an acid-resisting enamel and has an aluminum cover which also serves as a tray for the clothes. A height adjustment is provided.

TWO-WHEEL AUXILIARY drive units developed by the Rightway Corporation for attachment to several makes of tractors distribute the engine power to four drive wheels instead of two. The auxiliary drive wheels are placed inside and to the rear of the tractor wheels to increase road contact. Each wheel carries its own share of the weight, and, since the drawbar is attached at a point high on the bracket connecting the drive unit to the tractor axle, the drawbar pull results in a downward thrust on the positively driven auxiliary wheels to give still greater traction. Driving power, transmitted through the regular tractor differential and rear axle to the rear wheels, is carried from each of these wheels by means of a chain and sprocket to the end of a jackshaft, with a second differential mounted between its two elements. In the same housing, and to the rear of the jackshaft, is a solid axle carrying the auxiliary wheels driven by a chain from a sprocket mounted upon the cage of the jackshaft differential.



Dual coach chassis, showing method of mounting twin engines location of cross members, and arrangement for manipulating dual gearsets with a single control. Short drive shafts are notable



Automatic form-turning lathe, built by Monarch with Keller control. Magnetic-control motors, direct-mounted, drive the leadscrew and feed rod

ELECTRIC DISHWASHERS for home use introduced by the Conover Company incorporate flexible rubber-plated dishracks and Bakelite racks for silver. Washers have the appearance of a clothes washing machine and utilize an automatic measuring device to eject excess and to remove waste water electrically. The one-piece tank is porcelain enameled; the welded chassis is lacquered in green, blue, gray, or ivory, and parts are chromium plated. Oil-less bearings, an aluminum bronze impeller, and a low-starting load motor are incorporated.

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ALUMINUM PAINT is being used in a tiering truck manufactured by the Economy Engineering Company to make the units "visible from a distance and readily located in a large plant or dimly lighted warehouse." Trimming is in red and black.

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HAND MICROPHONES for use with home radios and "talkie" units are now being produced by a number of companies. The devices permit the operator to cut in to a radio or talkie program and have his voice heard through the loud speaker. The Kellogg hand microphone has a handle cast from aluminum with a case of formed brass. The back and stretching rings are machined from alloy steel and the diaphragm is of phosphor bronze. Proper contact of the diaphragm is gained by gold plating. The carbon button is insulated from the back with molded Kellite, a phenol-resin composition.

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New Specifications

FEDERAL Specification No. 138 for Ferro-Manganese, has been revised and is being submitted to industry for criticism and comment. A Federal Specification on Steam Hose Couplings is now being submitted also. Specification No. 339a on Metals, and No. 427a for Seamless Brass Tubing are being submitted for revision. Proposed American Standards for pipe flanges and fittings have been prepared by the ASA technical committee to cover pipe plugs of cast iron, malleable iron, cast steel, and forged steel; steel base-fittings for maximum steam working pressure of 250, 400, 600, and 900 lb. per sq. in., and steel companion flanges.

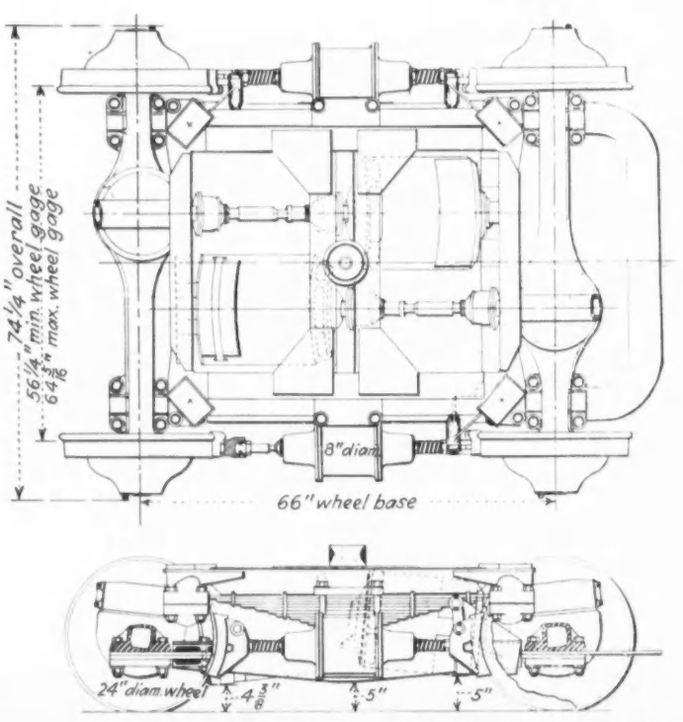
The proposed American Standards for Woodruff Keys has been submitted to the ASA for approval. A general review indicates that the committee has made no attempt to simplify or coordinate existing sizes, regularly produced by any given manufacturer, but instead has attacked the problem from the standpoint of the user.

Body Design Changes At the Auto Salon

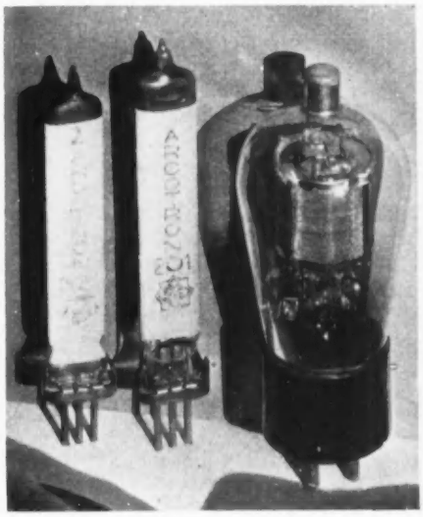
ALTHOUGH the New York Salon is primarily a body show, one completely new car, a Marmon with a 16-cylinder V-type engine, made its first bow, and the latest Lincoln with its new free-wheeling device and engine of considerably increased power was exhibited for the first time. Details of chassis or mechanical construction are not available.

Aside from a few freakish-looking bodies, novelties in body design were not numerous. Screen-covered radiators were common. Except those screens that were built-in, they appeared as if added as an afterthought. Chromium plating is being used more than ever. Stainless steel or chromium-plated strips are fitted on most running boards, and parts of fenders, in many cases, are protected by similar strips. According to the Duco Color Index, black, blue, green, and brown stand in popularity in the order named, whereas, the order a year ago read: blue, brown, black, and green.

Hudson's latest offerings, including the Essex, are not much changed mechanically, except for stiffer frames and cylinders of $\frac{1}{8}$-in. larger bore. Bodies have new lines and new fittings, and include detail structural refinements. The decreased price is said to be Hudson's lowest.



Worm-drive truck and new type of braking mechanism on General street railway car. Side-mounted brake cylinders, propeller unit disks for emergency braking, rubber insulation of metal parts, axle aligner, and wheel guards are incorporated



Indirectly-heated German a.c. radio tubes, utilizing electrostatic control. Metallic outer coatings replace the usual grid. Tubes are but ¼-in. thick; and life is tripled. Old-style tube is at right

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Aviation Design Trends

By Leslie E. Neville
Technical Editor, "Aviation"

ONE tendency in the past year in aviation has been toward simplification of cowlings. These new cowlings, although perhaps less efficient aerodynamically than the first ones developed, are considerably more desirable from the cooling and servicing standpoint. They are of the simple, quickly detachable ring type, adapted from British ideas, with highly desirable visibility features that in no way interfere with the normal cooling of the engine.

A similar condition has existed in the development of such units as wheel fairings. The first of these were designed to obtain aerodynamic refinement without thought of any other factor, but it was soon discovered that the best of airplane wheels must occasionally be serviced. Some of the aerodynamic gain had to be sacrificed to obtain the quick-detachable feature. Next year's engineering will probably show further advances in the maintenance features of airplanes.

The necessity of keeping even small protrudences out of the air stream has led to a number of interesting detail refinements, such as flush wing fittings, retractable steps, and some retractable oil coolers and radiators.

Gradual development of the Autogiro type has been under way during the year, and a number of detail improvements have been effected. These include mainly a mechanical engine-driven starter for the rotating vane system and a landing gear developed to meet the demands for long shock absorber travel in vertical landing.

Probably the feature in structural design has been the continuous trend toward the use of metal. The demand for aerodynamic cleanness has resulted in a number of interesting cantilever wing designs. Interesting developments in monocoque fuselage construction have been brought about. The Thaden and Towle wing structures are illustrated. In most of these wings the conventional spar and rib system is replaced by various other arrangements in which the metal skin carries a portion of the loads.

Most airplanes employ riveted aluminum alloys in their structures. In several quarters, however, research is progressing on the use of stainless steel, fabricated by electric spot welding. At the present time this movement has not progressed beyond the wing rib, but at least one airplane using such ribs has been fully approved by the Department of Commerce. A number of other manufacturers are investigating the possibilities of electric welding for steel tubing of the specifications normally used.

News of the Metal Markets

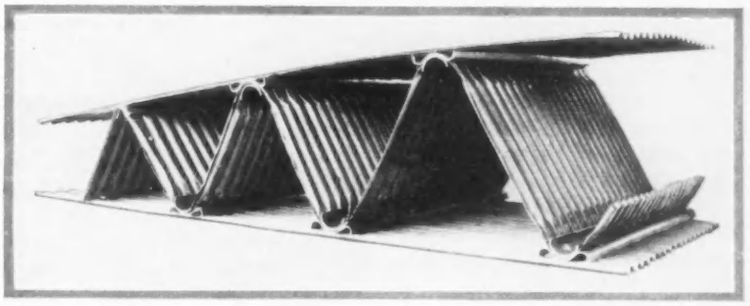
COPPER output, cut 12,630 tons in November, was still insufficient to stem the reaction to the 12-cent price. Price levels are now being stabilized at 10c. Recent declines in export prices have increased foreign buying to some extent, but the general total is low as a result of inventory-taking and unstable general conditions, according to *Metal & Mineral Markets*.

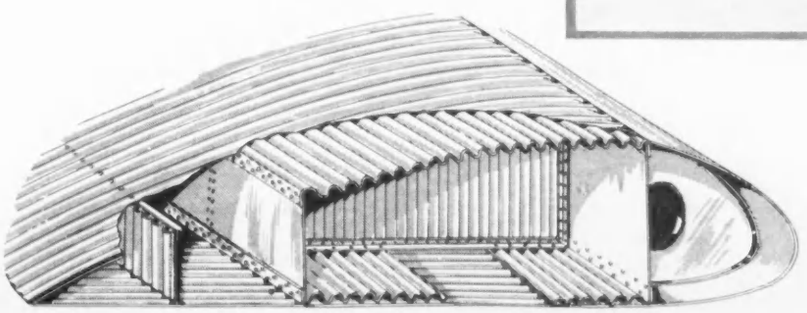
ZINC is steady in price at about 4c. on Dec. 19. Domestic production was curtailed sharply in November and will probably be further cut in December. Galvanizers and other users are, however, buying from hand-to-mouth to conform with business.

LEAD prices are steady at around 5c. with low demand. Babbitt, cable, and battery makers are taking only as much as they need at once. Ammunition makers are buying little, largely because of purchases earlier in the year, but foil makers seem to be taking less because of the advances in use of cellophane.

TIN, at 23½c. on Dec. 17, was at its lowest in 28 years, and sales at the low prices have been good, not so much of bettered position of users, but because they feel that tin at this price is a good investment.

MAGNESIUM prices have been lowered to 48c. the lb. in 100-lb. lots, with consequent increases in consumption of this exceptionally light metal.





Two advanced metal wing structures, the Towle (above) of Alclad, and the Thaden, of Duralumin. Towle uses corrugated sheet zigzagging from top to bottom of the wing section, with corrugations flattened at points of juncture. Thaden utilizes a smooth-sheet removable leading edge

IN THE SPOTLIGHT—

BANCROFT GHERARDI, vice-president and chief engineer of the American Telephone & Telegraph Company, has been elected president of the American Standards Association. CLYDE M. CHAPMAN, engineering specialist of New York City, was re-elected vice-president of the association. Mr. Gherardi has been a member of the Association's Board of Directors, and has been with the A. T. & T. since 1907, for the past 10 years in his present capacity. Mr. Chapman has been engineer in charge of design and tests for several organizations at various times. He will also be chairman of the ASA Standards Council.

T. AMORI, professor of engineering at the College of Port Arthur, and DR. M. ISHIKAWA, professor of engineering at the College of Tokyo, are returning to Japan from Europe by way of the United States and are spending a month in this country inspecting some of the leading manufacturing plants and engineering schools.

ROY F. ANDERSON has resigned as vice-president in charge of engineering of the Hayes Body Corporation, Grand Rapids, Mich., and has become sales engineer with the Murray Corporation of America, Detroit.

FRED A. BENZ, chief executive of the Benz Engineering Corporation, Salamanca, N. Y., has been elected mayor of that city to succeed Bert L. Hunt, who died recently. Mr. Benz was chosen by the City Council at the request of leading business men of the city. He will hold office until Jan. 1, 1932.

OSCAR C. BORNHOLT, former president of the Oakes Products Corporation, North Chicago, Ill., has become a research engineer with the Houdaille-Hershey Corporation, Chicago.

ELLIOTT DALAND, formerly an engineer with the Keystone Aircraft Corporation, Bristol, Pa., has joined the Kellett Aircraft Corporation, Philadelphia, in a similar capacity.

N. E. DRULET, formerly experimental engineer with the Wilkening Manufacturing Company, Philadelphia, has become sales manager and engineer for the Budlong & Funchess Motor Products Company, Hanford, Calif.

W. H. HIMES, formerly in the mechanical engineering department of the Westinghouse Electric & Manufacturing Company, Pittsburgh, Pa., has been promoted to manager of the Engineering Department to succeed L. F. BURNHAM, resigned.

T. S. FULLER, metallurgist of the General Electric Company, Schenectady, N. Y., will speak on "Metallurgical Problems in the Electrical Manufacturing Industry" at the Jan. 12 meeting of the New York chapter, A.S.S.T. The Dec. 8 meeting was a visit to the Union Carbide & Carbon Research Laboratories.

WILLIAM W. DUNNELL, JR., formerly production engineer with Comstock & Westcott, Inc., Cambridge, Mass., has become a machine designer with the Reece Buttonhole Machine Company, Boston.

JOHN HOWE HALL has been appointed technical assistant to the president of the Taylor-Wharton Iron & Steel Company, Highbridge, N. J. He will have full supervision of all research activities and be general adviser on manufacturing methods and sales engineering.

Bancroft Gherardi

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Clyde M. Chapman

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W. H. Himes

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A. J. FOLEY resigned recently from the Engineering Department of Sargent & Lundy, Inc., Chicago, Ill., to become manager of the Chicago Sales Office of the Beilan Company, Ltd., Los Angeles, Calif.

JOHN J. GRABFIELD, formerly project engineer in the General Motors Research Laboratory, Detroit, has become a test engineer with the Hudson Motor Car Company, also of Detroit.

R. H. GRUBB has joined the engineering department of Igoe Brothers, Newark, N. J. He was formerly office manager, reinforcing bar department.

H. A. HUEBOTTER, formerly research engineer with the Waukesha (Wis.) Motor Company, has become an instructor in automotive engineering for the General Motors Institute of Technology, Flint, Mich.

LORENZ IVERSON, considered as one of the outstanding steel works engineers in the country, has been elected president of the Mesta Machine Company, West Homestead, Pa., to succeed the late Harry F. Wahr.

E. C. JACKSON, JR., has resigned as head of the Department of Mechanical and Electrical Engineering at the Speed Scientific School, University of Louisville, to assume the duties as head of the Department of Electrical Engineering, University of Kansas, Lawrence.

W. F. JOHNSTON, associated for the past four years with Allied Engineers, Inc., New York, recently took a position with the Stone & Webster Engineering Corporation, Boston, Mass., as engineer of the mechanical division.

FREDERICK KNACK, formerly secretary for Aerotach, Inc., Moline, Ill., has become chief engineer for the Mono Aircraft Corporation, also of Moline.

KONRAD LANGER, formerly a designer with the Brooks Steam Motors, Inc., Buffalo, has become a layout draftsman for the Curtiss Aeroplane & Motor Company, also of Buffalo.

RALPH S. MACPHERRAN, chief chemist of the Allis-Chalmers Manufacturing Company, Milwaukee, an outstanding metallurgist in the gray iron foundry field, has been awarded the J. H. Whiting gold medal of the American Foundrymen's Association.

R. H. MANSON, vice-president and chief engineer of the Stromberg Carlson Telephone Manufacturing Company, Rochester, N. Y., was recently nominated for the presidency of the Institute of Radio Engineers, an international body having members in this country and abroad.

WILLIAM B. MAYO, chief engineer of the Ford Motor Company, was appointed by Governor Green of Michigan to represent Michigan at the National Conference on Uniform Air Laws in Washington, Dec. 16 and 17. Mr. Mayo is chairman of the Michigan Board of Aeronautics.

J. P. MILLER, formerly engine designer for the Studebaker Corporation, South Bend, Ind., has become chief draftsman in the engine division of the Dee Wite Boat Co., Detroit.

T. E. TILLINGHAST, executive engineer of the Pratt & Whitney Aircraft Company, Hartford, Conn., has been elected a director, and has charge of all outside engineering activities under A. V. D. WILLGOOS, chief engineer. Mr. Willgoos will also be assisted by L. S. HOBBS, research engineer, and EARL A. RYDER, assistant to the chief engineer.

H. G. OSBORN, engineer in the Osborn Engineering Laboratory, Owosso, Mich., has joined the Essex Wire Corporation, located in the west portion of the Ford plant at Highland Park, Mich.

FRED E. KLING, chief engineer of the Youngstown district for the Carnegie Steel Company, has been appointed chief engineer of all Carnegie plants, with headquarters in Pittsburgh.

R. E. W. HARRISON presented a paper entitled "Survey of Surface Quality Standards and Tolerance Costs, Based on 1929-1930 Precision Grinding Practice" at one of the Machine Shop Practice sessions during the A.S.M.E. annual meeting. In his paper, Mr. Harrison described not only a new method of evaluating ground finishes, but also the apparatus for comparing and calibrating finishes on a production basis.

MAURICE OLLEY, British engineer, and for 11 years chief engineer of the Chassis Division of the Rolls-Royce Company of America, has joined the engineering staff of the Cadillac Motor Car Company.

WILLIAM H. RAGSDALE, formerly experimental engineer with the Lycoming Manufacturing Company, Williamsport, Pa., has joined the Davis Devices Company, Clarksburg, W. Va., in a similar capacity.

F. D. NEWBURY, formerly manager of the Power Engineering Department, Westinghouse Electric & Manufacturing Company, has been appointed general manager of machinery engineering. Mr. Newbury has been with the engineering department since 1903. Succeeding him as manager is R. A. MCCARTY, formerly division engineer in the department.

STANLEY A. RICHARDSON has been appointed chief metallurgist of the reorganized Empire Steel Corporation, Mansfield, Ohio. PAUL LLEWELLYN, formerly president of the Interstate Iron & Steel Company, Chicago, has been elected chairman of the board of the reorganized company.

ROBERT C. SESSIONS, until recently engineer in charge of the engineering and experimental division of Steel & Tubes, Inc., Cleveland, has become affiliated with FRANK L. SESSIONS, consulting engineer, with headquarters in the Rockefeller building, Cleveland. They will practice consulting mechanical and electrical engineering.

C. A. THAYER, formerly chief engineer for the Arthur G. McKee & Co., steel works project in Soviet Russia, has been appointed vice-president in charge of operations of the Republic Steel Corporation, Youngstown, Ohio.

T. E. Tillinghast

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R. E. W. Harrison

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F. D. Newbury

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R. A. McCarty

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CAPT. H. LEDYARD TOWLE has been appointed general art director of the Campbell - Ewald Company. Captain Towle comes to Campbell-Ewald from the Fisher Body Corporation, where he acted as director of the color and advertising art studio. He was previously director of the Duco Color Advisory Board.

H. R. VOORHEES, now a designer for the Hupp Motor Car Company, Detroit, was previously with the Verville Aircraft Company, Detroit, in a similar capacity.

E. S. WALLACE, formerly mechanical engineer of the Detroit plant, Chevrolet Motor Company, has been made plant manager at Bay City, Mich.

FRANK A. WHITTEN, for the last two years chief engineer of the McCord Radiator & Manufacturing Company, Detroit, has become engineering specialist in public utility securities with Bonbright & Company, Detroit.

RAYMOND C. WILSON, formerly designer with the International Motor Company, Long Island City, New York, has become an engineer with the Chain Saw Corporation, also of Long Island City.

Obituaries

ISAAC W. FRANK, 75, formerly engineer and secretary of the Louis Foundry & Machine Company, Pittsburgh, and organizer of the Frank-Kneeland Machine Company, which later became one of the units of the United Engineering & Foundry Company, died on Dec. 1 at his home in Pittsburgh.

JAMES G. DORNBIRER, 63, founder of the Cleveland (Ohio) Planer Company, and inventor of an open-side steel planer, died on Nov. 27 at his home in Cleveland after a long illness. He retired 12 years ago, and later became honorary president of the Dornbirer Machine Tool Company, Cleveland.

JAMES BROWN HERRESHOFF, 96, inventor, died on Dec. 5 at his home in Riverdale, N. Y. He invented and constructed the first naphtha-driven motorcycle of internal combustion type in America, the coil boiler, and the fin keel for sailing yachts.

FREDERICK K. HANNAH, 55, consulting engineer, died on Dec. 4 at his home in New York City. He returned recently from Russia.

ANDREW MURRAY HUNT, 71, electrical and mechanical engineer, died in Berkeley, Calif., on Dec. 8. During the war he was a member of the Naval Consulting Board, and also consulting engineer for war material firms.

NATHAN W. PERKINS, 71, mechanical engineer, for many years with the Ellis Adding Machine Company, Newark, N. J., died on Dec. 1 at his home in East Orange, N. J. He was also at one time with the National Cash Register Company.

NEW MATERIALS AND PARTS AND ENGINEERING EQUIPMENT

"Wyr-omat-ick" Clearance Compensator

CONSTANT clearance in bearings is maintained automatically by means of the "Wyr-omat-ick" compensator announced by the Wyrick Engineering Company, Wyandotte, Mich. If excess clearance is permitted between parts having lateral movement under more or less force, the resultant pounding tends to increase such clearance, rendering the latter rapidly accelerative. By taking up such play, this compensator avoids the accelerative action and prolongs the useful life of the bearing and of reciprocating parts. In fact, a burnishing action takes place in bearings, with the result that the bearings become highly polished and the friction is reduced. Necessity of machining to close limits is eliminated, and lighter bearings may be employed.

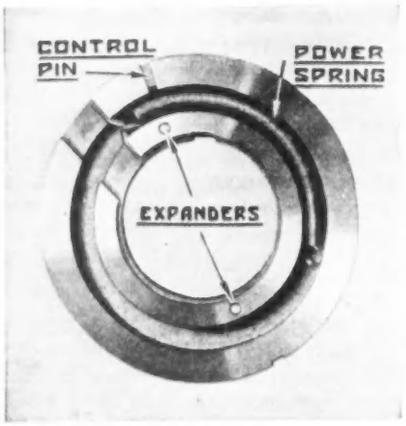


Fig. 1—Smooth cam of the Wyr-omat-ick compensator

Fig. 2—The slotted cam, showing the integral control ribs

The major parts are two mating helical cam-faced members, Figs. 1 and 2, which when placed together as shown in Fig. 3, will increase or decrease their joint cross-sectional dimension if rotated in opposite directions. These two members serve the space-filling requirements which are necessary as wear occurs. The power spring, illustrated in Fig. 1, which is attached to both cams when assembled, provides the power to rotate the cammed members whenever this action is required.

The expanders, illustrated in Fig. 1, are two hardened steel balls with expansion springs in back urging them outward to exert a pressure against the inner surface of the slotted cam when the cams are placed face to face as shown in Fig. 3. This action insures separation of the two cam-faces as through wear or other factors increased space occurs.

The T-shaped control pin is ground to project beyond the face of the smooth cam, in which it is assembled, a distance equal to the desired clearance. Thus, when the cams are placed as shown in Fig. 3, the control pin projects into one of the slots of the slotted cam and engages one of the ribs of the latter, insuring against any rotational action between the two cams unless sufficient space is allowed to permit the cam-faces to separate a distance equal to the protruding portion of the control pin.

Fig. 3—Case removed from compensator to show the relation of the control pin with the control ribs

The ribs of the slotted cam are spaced to insure the desired dimension of readjustment required at each readjustment period. For example, if the total cam rise equals 0.062 in. and it is desired to readjust at each 0.001 in. increment of wear, then 31 ribs would be milled (equally spaced) on one-half of the cam-face; thus the thickness of the cam would be 0.001 in. greater at each rib up the cam surface. These increments can be made to suit individual requirements, and the total number of ribs also.

The compensator is further provided with a locking seal. This seal holds the cams in their reduced dimension relation until the compensator is properly assembled in working position between two spaced parts,

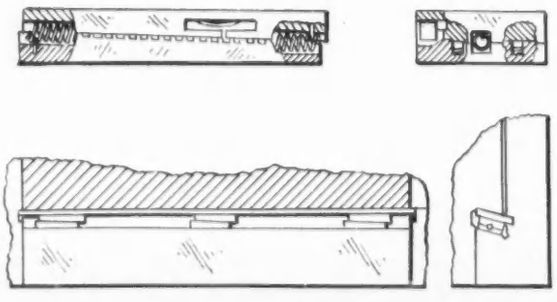


Fig. 4—"Wyr-omat-ick" Compensator for gibbed ways and other sliding bearings

after which it is removed. Then the compensator acts merely as a precision spacing washer, readjusting action taking place only at intervals when, through wear or other factors, the combined clearances of the assembly reach the predetermined maximum.

The various members co-act in the following manner: Inserted between two spaced parts with the compensator reduced to minimum dimension, the power spring urges opposite rotation of the two cammed members, and such rotational action is restrained by a control rib obstructing passage of the control pin; the expanders continually urge separation of the cam-faces and as wear takes place and space is provided the cams gradually separate until the control pin has clearance to pass the obstructing rib. Then the power spring enforces opposite rotation of the cams and this action increases the joint dimension of the cammed members, closing the space between the cam-faces, thereby compensating for the increased clearance. The control pin is again obstructed from passing the next rib in the series, and the compensator unit again acts as a mere spacing washer until further wear permits another readjustment cycle. Any maximum or minimum limits of clearance may be maintained automatically until the maximum capacity of the compensator has been reached.

All compensators are made special in shaft sizes from ½ to 6 in.

Trent Electrical Heating Elements

IMMERSION-TYPE electrical heating elements have been added to the line manufactured by the Harold E. Trent Company, 439-43 No. 12th Street, Philadelphia, Pa. The Type IR Junior immersion unit is illustrated at the right.

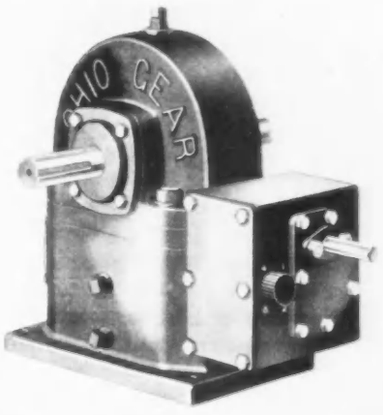
These heating elements have been constructed to be interchangeable with other elements of a similar character. The correct relationship between the area of the heating element and the outside casing has been determined in order to provide sufficient surface to radiate the heat generated in the element. If desired, a single-heat element may be replaced by a three-heat type.

For stock purposes the element is supplied with a seamless brass tube, but bodies made of copper, steel, or chrome alloy steel are available. For the ordinary elements, the heat is distributed over the entire length, although when necessary heat concentration at different positions along the tube can be provided.

Ohio Speed Reducer with 4-Speed Gear Shift

BY MEANS of a selective dial, any one of four speeds can be obtained from the worm-gear speed reducer announced by the Ohio Gear Company, 1333 E. 179th St., Cleveland, Ohio. A complete range of sizes is available from 3 hp. to fractional horsepower sizes of ¾ and ⅛ hp.

In this worm-gear speed reducer, the worm and worm wheel assembly provides the main reduction. The speed changer gear ratios can be varied within fairly wide limits, although two alternative sets of ratios, which have been standardized, are usually found sufficient. The first alternative varies the revolutions per minute in the proportions of 1 to 1, 1½ to 1, 2 to 1, and 3 to 1, as compared with the worm wheel revolutions. The alternative standard varies as 2 to 1, 1.87 to 1, 1.66 to 1, and 1.6 to 1. These ratios must be multiplied by the ratio of the worm gear reducer to which the speed-changing part is attached, in order to give the ultimate reduction.



Ohio Combination Worm-Gear Speed Reducer and 4-Speed Changer Unit, showing the gear-shift knob

Trent Type IR Junior Immersion-Type Electric Heating Element

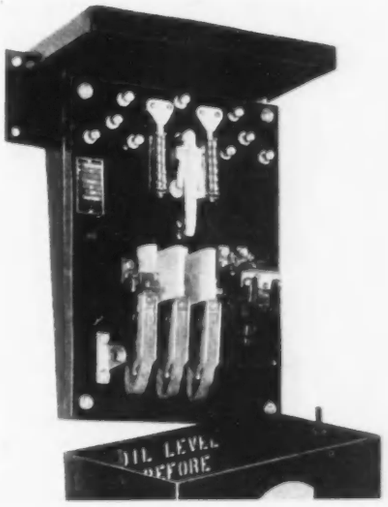
A hardened and ground steel worm is employed, while the worm wheel is of bronze. Reducer shafts run in ball-bearings and the edges of the speed-changer gear teeth are rounded to facilitate easy engagement. The mechanism is so designed that the "gear shift" dial cannot be operated unless the unit is at rest. Both the box and worm assembly can be arranged for any operating position specified. The speed changing box can also be supplied separately, if desired.

Monitor Oil-Immersed Starter

ACROSS-THE-LINE, full voltage starting is permitted by the oil-immersed "Thermaload" starter announced by the Monitor Controller Company, Baltimore, Md. This device is equipped with overload and low-voltage protection, and consists of a magnetic contactor mounted on a panel with a thermal relay, and enclosed in an oil-tight box. The oil completely immerses the contactor and the contacts of the relay.

This starter gives positive protection to polyphase and single-phase motors both while starting and while running. It will prevent damage to polyphase motors from running single-phase, in case one of the phases goes dead.

The N.E.M.A. ratings are as follows: 7½ hp. at 110 volts; 15 hp. at 220 volts, and 25 hp. at 440 volts.



Enclosing box removed from Monitor Oil-Immersed Thermaload Starter to show the magnetic contactor and thermal relay

NEW MATERIALS AND PARTS

Wazau Hardness Tester

A PORTABLE hardness tester for Brinell tests, and also arranged to measure the depth of indentation similar to the Rockwell method, has been placed on the market by the Southwark Foundry & Machine Company, Testing Equipment Division, Philadelphia, Pa. The tester is suitable for both shop and laboratory use. It is light in weight, and no electrical connections are necessary.

Wazau Hardness Tester which is arranged for measuring both diameter and depth of impression

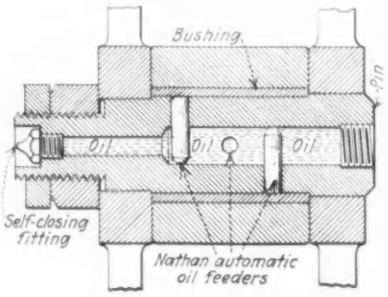
The load is applied by a hand-driven screw and measured by an elastic precision ring dynamometer and dial graduated in 10-kg. divisions. The vertical opening of the press is 4 in., and can be decreased by inserting blocks. The supporting table is of the overhung type to accommodate ring-shaped pieces.

An innovation in this machine is the arrangement of the hollow bronze screw containing the main screw. It is rotated automatically when turning the main screw under small loads, but at higher loads the screws disengage automatically, letting the main screw exert the final load. By this construction, the diameter of the smaller screw can be made reasonably small, enabling easy operation of the machine.

The indentation produced is measured by a special instrument furnished with the machine. The diameter of the impression is read in hundredths of a millimeter. Measurement of the depth of impression can also be taken with the Wazau tester, by observing a scale geared to the main screw. It indicates the vertical movement of the spindle in hundredths of a millimeter. Scale divisions are of sufficient width to permit estimating to fifths, equivalent to 0.002 mm. Rockwell values are obtained by multiplying the readings of this scale by five.

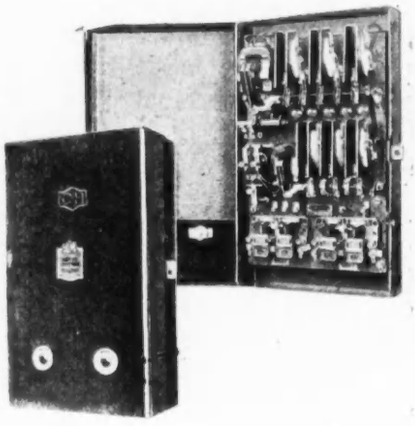
Nathan Automatic Oil Feeders

FOR industrial applications, the Nathan Manufacturing Company, 250 Park Ave., New York, N. Y., is offering its automatic oil feeders. Oil reservoirs are built into the parts equipped with this lubricating system. In the holes which connect reservoirs and bearing surfaces, oil feeds or plugs are fitted for carrying the oil to the bearing surfaces. They are made of specially selected wood, treated to feed oil from the reservoirs in minute quantities to lubricate the bearing surfaces thoroughly. Sand or grit is prevented from reaching the surfaces, thus assuring long bearing life.



Cutler-Hammer Bull. 9739 Controllers

TWO-SPEED, consequent-pole-type (reconnected), squirrel-cage motors can be controlled by means of the Bulletin 9739 automatic controller developed by Cutler-Hammer, Inc., 2-12th St., Milwaukee, Wis. This controller functions to start the motor and to change its speed by reconnecting the motor windings. It provides thermal overload protection at both motor speeds and low voltage protection. A separate push-button master switch with "stop," "low," and "high" buttons provides three-wire remote control.

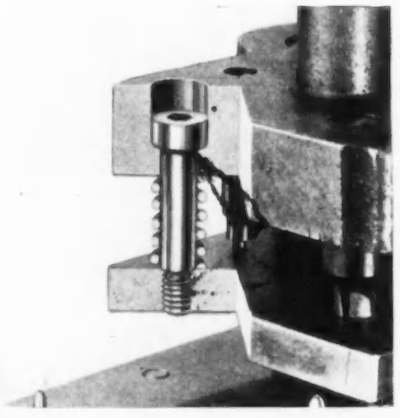


This controller is furnished for constant - horsepower, constant-torque, or variable-torque motors. A sequence compelling feature can be furnished, which makes it necessary to start the motor always on low speed before bringing it up to high speed, and thus protect the driven machine.

Allen Socket-Head Shoulder Screws

COLD-DRAWN, socket-head shoulder screws are now being manufactured by the Allen Manufacturing Company, 133 Sheldon St., Hartford, Conn. These screws are stocked in several body diameters and many shoulder lengths adapted for holding together a great variety of machine parts and for cam attachments. The screws are heat-treated.

These socket-head screws are made in four sizes of hexagonal sockets—



Showing how Allen Socket-Head Shoulder Screws are employed as stripper bolts in production machinery

NEW MATERIALS AND PARTS

$\frac{3}{16}$, $\frac{1}{4}$, $\frac{5}{16}$, and $\frac{3}{8}$ in. across flats. Corresponding shoulder diameters are $\frac{3}{8}$, $\frac{1}{2}$, $\frac{5}{8}$, and $\frac{3}{4}$ in. Shoulder lengths for the $\frac{3}{8}$-in. size range from $1\frac{1}{4}$ to 4 in., for the $\frac{1}{2}$-in. size from $1\frac{1}{4}$ to 5 in.; for the $\frac{5}{8}$-in. size from $1\frac{1}{2}$ to 6 in., and for the $\frac{3}{4}$-in. size from $1\frac{1}{2}$ to 8 in.

Reliance
Large Fan-Cooled Motors

BY employing the Mossay principle of cooling to large, inclosed, fan-cooled motors, the Reliance Electric & Engineering Company, 1088 Ivanhoe Road, Cleveland, Ohio, can supply motors from 20 to 150 hp., interchangeable in mounting dimen- with standard open motors.

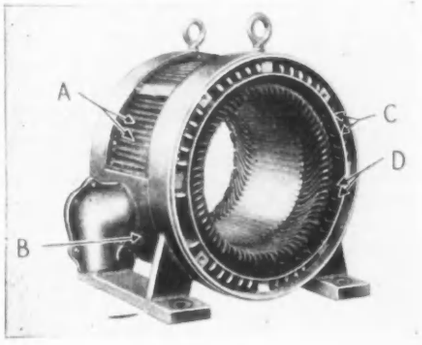


Fig. 1—Stator of Reliance Large Fan-Cooled Motor

The extra cooling area obtained with this principle is obtained by the use of tubes *A*, Fig. 1. A single internal fan on the rotor circulates the confined warm air through the tubes. A steel enclosing band *B* forces the cool air to follow along the outside of the tubes from one end of the motor to the other. Legs of the tubes are welded into the inside header *C*. Warm air enters the cooling tubes through openings *D*.

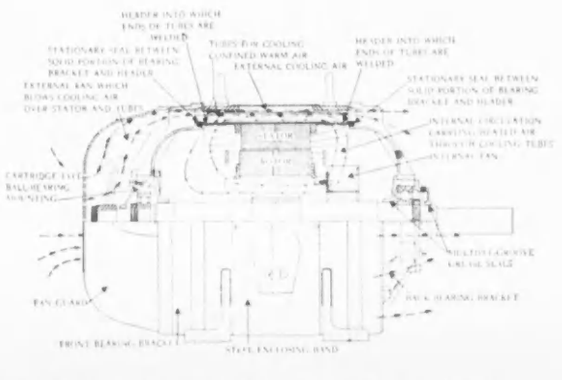
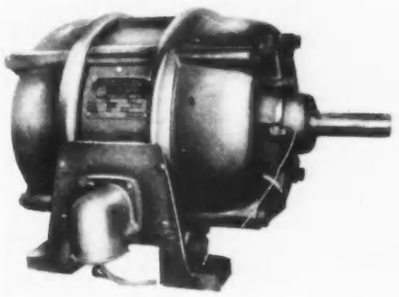


Fig. 2—Cross-section of Reliance Fan-Cooled Motor

"Ideal"
Unit-Type Motors

INDUCTION, squirrel-cage, slip ring, and d.c. motors, in all sizes and types from $\frac{1}{2}$ to 200 hp., are now available from The Ideal Electric & Manufacturing Company, Mansfield, Ohio, in unit designs. Standardization of these designs has permitted interchangeable rotors and stators. Thus, standard horizontal motors, shell-type motors, flange-type motors, vertical motors, and special applications of "built in" motors requiring only the active elements, all take the same rotors and stators.

These standardized units are used to build open-type motor, splash-proof motors, drip-proof motors, totally inclosed, fan-cooled motors with running seals or stationary seals, explosion-proof motors, and shaftless motors. Precision in manufacture assures proper alignment of all motors and replacement of parts when required. Sleeve bearings, shafts, stators and rotors and armatures are all ground to definite measurements with limit tolerances. Because of the unit type design active motor elements can be built in the machine at low cost and with only minor changes in the present machine.

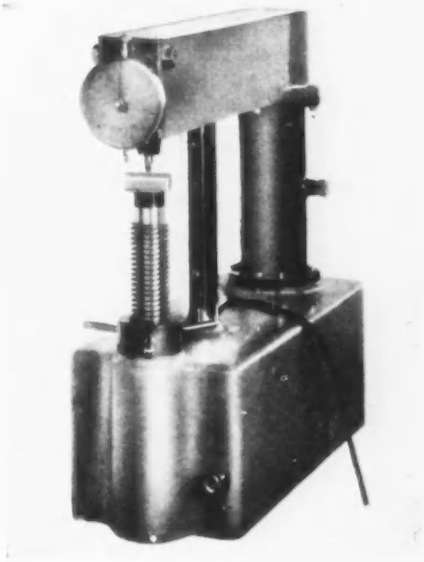


Ideal Unit-Type Motor employing standardized stators and rotors to facilitate building open or closed types

Anti-friction bearings are supplied as standard. They are of the cartridge type, and direct fittings with automatic seals are used to supply grease under pressure. Sleeve bearing housings can be rotated for wall or ceiling mounting without removing the bearing brackets. They can also be replaced without removing brackets.

"Diamo"
Brinell Hardness Tester

BRINELL hardness readings are read directly on the "Diamo" Brinell hardness tester placed on the market by the Pittsburgh Instrument & Machine Company, 1026 Reedsdale St., Pittsburgh, Pa. The instrument is operated by a system of weights and levers and the indentation is produced by a diamond semi-ball of 2 mm. diameter under a load of 120 kg. After the test piece is placed in position and the motor is started, it is necessary only to pull out the "starter" at the front of the base to apply the load automatically. The load is then released automatically. For soft material the test load can be changed easily from 120 to 30 kg.



"Covulc"
Self-Curing
Plastic Rubber Compound

PROTECTION of varied equipment subject to extreme wear or corrosion can be effected with "Covulc" self-curing plastic rubber compound manufactured by The Hitchcock Company, 48 Pearl St., Boston, Mass. It can be quickly applied and requires

NEW MATERIALS AND PARTS

no heat nor pressure. It is supplied in paste form. One pound of "Covulc" will cover approximately 3 sq.ft., if spread to an average thickness of $\frac{1}{4}$ in.

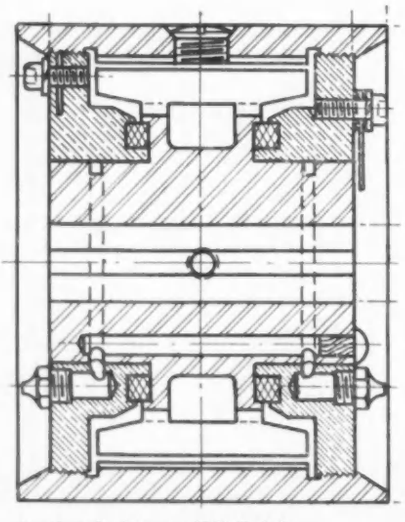
A typical application of "Covulc" is the covering of metal parts where corrosive or acid conditions exist. Exposure to air causes the material to cure. After vulcanizing, it remains soft and flexible.

Hill-Pulvis Centrifugal Clutch

SURE, gradual power transmission by centrifugally increasing density of graphite-treated chilled shot against a driving and a driven element is the principle employed in the Hill-Pulvis clutch announced by The Hill Clutch Machine & Foundry Company, Cleveland, Ohio. This type of clutch can be applied to individual drives, either as a motor pulley, V-belt sheave, gear or sprocket, or as a coupling on direct-connected drives.

Referring to the illustration, the winged rotor is the driving element and the serrated shell is the driven element. Wings are provided with orifices to distribute the chilled shot evenly, thus effecting dynamic balance during its operation. When the line switch is closed, the driving motor comes immediately up to speed. The winged wheel turns at the same speed and rotates the charge of chilled shot. The rotating rotor wings set up centrifugal action, forcing chilled shot out against the serrated inner surface of the shell. The chilled shot mass packs tightly and assumes a definite position in front of each wing. Power is transmitted in gradually increasing amounts until the maximum is reached without loss to the driven element. Every clutch is equipped with a "tell-tale" device that indicates duration of starting time and shows overloading.

Both starting characteristics and driving power can be changed in the same clutch by changing the quantity of chilled shot.



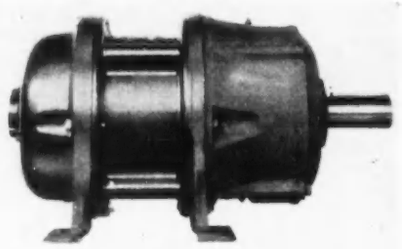
Sectional view on Hill-Pulvis automatic clutch pulley

Components of the Hill-Pulvis clutch, which employs chilled shot as the driving medium

Watson-Flagg Front-Gear Motors

HELICAL-GEAR reduction units are built into the end shield of a standard electric motor to form front gear motors, a product of the Watson-Flagg Machine Company, 107 Nineteenth Ave., Paterson, N. J. Except for a very slight increase in overall length, together with a larger shaft diameter than usual, because of the lower speed involved, the combination is practically the same in appearance as the motor alone. The wide-spread, double-bearing supports for the output shaft extension permit the application of these units on overhung load conditions, such as V-belt or roller chain take-offs, in addition to the usual coupling connection.

The front gear motors are equipped with anti-friction bearings throughout, and are dust-proof and oil-tight. Standard N.E.M.A. motor frames are employed, and the combination is entirely supported on the regular motor feet. No unit bedplate is required. Therefore, the Watson-Flagg front-gear motor may be placed on any mounting pad suitable for standard motors.

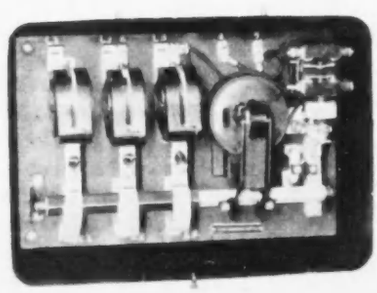


Watson-Flagg Front-Gear Motor, which employs a standard N.E.M.A. frame and built-in helical-gear reduction

These front gear motors are available for any speed motor from 3,600 r.p.m. down and from $\frac{1}{6}$ to 30 hp. Stock ratios are $11\frac{2}{3}$:1, 11:1, $10\frac{1}{3}$:1, 9:1, 8:1, 7:1, 6:1, 5:1, and 4:1.

General Electric Magnetic Switch

FOR use on either a.c. or d.c. circuits, the General Electric Company, Schenectady, N. Y., has announced the CR-2811 magnetic switch, which is provided with a latch to hold the contactor closed. This condition is particularly desirable for conditions where: (1) the hum of a standard



NEW MATERIALS AND PARTS

magnetic switch must be eliminated; (2) where the power consumed to hold the contactor closed by the usual method must be eliminated because of cost, and (3) where the switch must not open in case of coil failure, power failure, or short circuits.

The device consists of a two- or three-pole, a.c. contactor with a latching mechanism mounted on a base and with or without an enclosing case. The contactor is standard except for an extension of the shaft for the latching mechanism.

"I-C" Manual Starter with Push-Button Reset

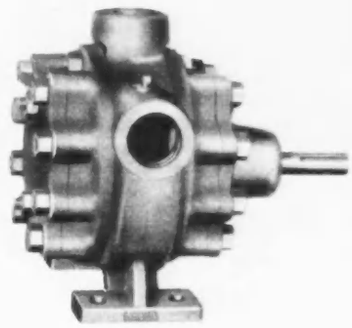
ALL poles of the Class 2510 manual starter, introduced by the Industrial-Controller Division, Square D Company, Milwaukee, Wis., are opened simultaneously with the tripping of either of two relays. The thermal overload relay used is the same type employed on the automatic starters manufactured by the company. The starter is reset for operation by pressing the button extending through the front cover. Another feature is the trip-free handle, which prevents blocking of the switch closed against

an overload. As the starter is operated entirely from the front, it may be mounted in pairs or groups on a pedestal or a wall without waste space.

The three-phase ratings of this starter are: 5 hp., 220 volts; and 7½ hp., 440-550 volts. It is suitable for pumps, portable conveyors, fans, and other applications where low-voltage protection is not required.

Roper Series 909 and 911 Hydraulic Pumps

TWO series of geared pumps for use in machine tools, hydraulic feeds, and for accumulator tank service have been developed recently by the George D. Roper Corporation, Rockford, Ill.

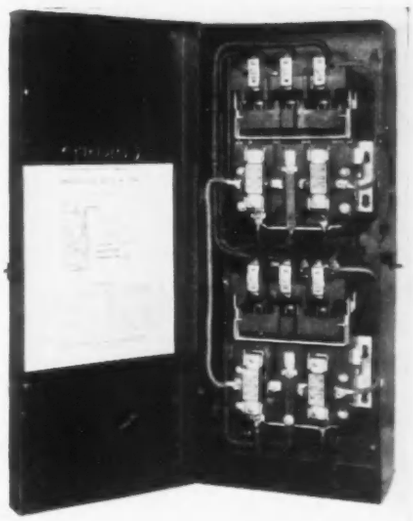


Both series of pumps have ball bearings and herringbone gears, insuring quietness of operation, high mechanical efficiency, and the absence of trapping of oil when teeth mesh. They may be furnished stripped, or mounted for belt, chain, or motor drive.

The Series 909 pump is made in four sizes, Nos. 2, 3, 4, and 5, delivering from 5 to 50 gal. per minute at a pressure up to 1,000 lb. per sq.in. The Series 911 pump is made in nine sizes, delivering from 3 to 100 gal. per minute at a pressure up to 300 lb. per sq.in. Both types are suitable for lubricating liquids only. If chain or belt drive is desired an outboard bearing can be supplied.

Condit Type A-30-R Air Motor Starter

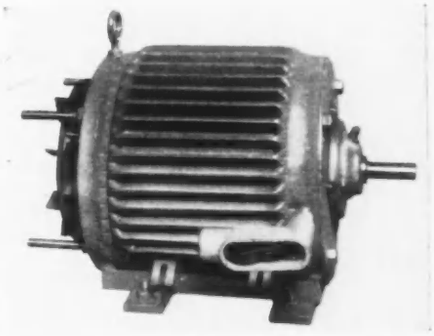
A REVERSING across-the-line air motor starter for the control and protection of squirrel-cage induction motors has been placed on the market by the Condit Electrical Manufacturing Corporation, Boston, Mass. The starter, known as the type A-30-R, consists of two of the type A-30 arc prevention motor starters mounted in an inclosing case and mechanically interlocked. Both starters are equipped with thermal relays for time-lag overload protection. The type A-30-R starter is furnished for push-button control up to 20 hp., 550 and 440 volts; 15 hp. 220 volts, and 7½ hp., 110 volts.



"Linc-Weld" Totally Inclosed Fan-Cooled Motors

ARC-WELDED steel construction is employed in the line of "Linc-Weld," totally inclosed, fan-cooled motors announced by the Lincoln Electric Company, Cleveland, Ohio. These motors also employ double-sealed ball bearings and a removable cover that facilitates easy cleaning of the large radiating surface. The temperature rise is considerably less than the allowable rise for motors of this type.

The illustration shows the motor



Cover removed from "Linc-Weld" Totally Enclosed, Fan-Cooled Motor to show the corrugated radiating surface made of corrosion-resisting metal

NEW MATERIALS AND PARTS

with the steel cover removed to expose the corrugated radiating surface. This conducts the heat created within the motor to its outer radiating surface, which is constantly cooled by a continual draft of fresh air from a fan on the motor shaft. Air imprisoned within the corrugated frame is constantly circulated by a fan arc-welded to the rotor. The corrugated cooling surface is easily accessible as shown for cleaning.

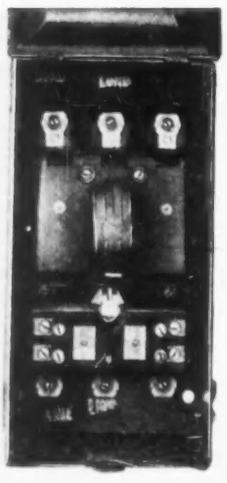
These "Linc-Weld" motors have the same mounting dimensions as standard, open-type, horizontal motors of equal rating. Sizes manufactured are from 1 to 50 hp.

Westinghouse Type WK-16 Switch

A MOTOR starting switch especially suitable for use with textile loom and machine tool motors has been placed on the market by the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., under the trade name of "Motor Watchman." This is a small, simple, and inexpensive motor starting switch with resettable automatic overload protection. All ratings are inclosed in the same size box, $4\frac{7}{8}$ in. wide, 9 in. long, and $3\frac{1}{16}$ in. deep. Therefore, it is possible for machine tool builders to design for and stock only one size box.

Tripping the contacts of the automatic overload protection device is effected by heating a preformed bimetallic disk, which does not gradually deflect but maintains its shape up to a predetermined point. When this point is reached the disk snaps to another position affording a positive tripping means.

The door of the switch is hinged at the top and the operating mechanism is of the quick-make and quick-break toggle type, with cadmium plated parts and non-corrosive bearings. The heater coils can be changed.



PUBLICATIONS

FOR THE ENGINEERS' LIBRARY

CHAIN, "PROMAL." The Link-Belt Co., 200 South Belmont Ave., Indianapolis, Ind., has prepared a 32-page data book devoted to Promal chains for power transmission and conveying services. The booklet, No. 1050, describes both plain links and attachments, and gives the dimensions, strengths, list prices and weights.

GEARS. The Ohio Gear Co., 1333 E. 179th St., Cleveland, Ohio, has published a 96-page No. 30 catalog on small and medium-size gears in spur, bevel, miter, spiral, and other types. It is provided in handy pocket-size form with formulas and information on the design and adaptation of gearing and reduction units.

GEAR CATALOGS. The Boston Gear Works Sales Co., North Quincy, Mass., has issued booklets as follows: "Boston Gear Products from Stock" covering gears, speed reducers, and chain drives; "Renold-Boston Chain Drives from Stock"; "Boston Gear Speed Reducers from Stock", and "Shaft Supports from Stock."

GEARS, HERRINGBONE. The W. A. Jones Foundry & Machine Co., Chicago, Ill., has issued a 40-page booklet on herringbone cut gears, listing the various pitches in three different face widths in both cast iron and steel. These gears are cut by the Sunderland method.

GENERAL ELECTRIC PUBLICATIONS. The General Electric Co., Schenectady, N. Y., has issued the following bulletins: GEA-140A on type CR1034-K1 hand starting compensators for squirrel-cage induction motors; GEA-579B, superseding 579A, on automatic full-voltage controllers for synchronous motors; GEA-841A on type CR7006-D40 magnetic switch for induction motors; GEA-1254 on Textolite molded control pulleys for aircraft; and GEA-1326 on totally enclosed, fan-cooled induction motors, type K.

HEATING ELEMENTS. The Harold E. Trent Co., 439 North 12th St., Philadelphia, Pa., has published Leaflet TA-29 on its electric heating elements and units for all industrial equipment for element temperatures ranging up to 1,900 deg. F.

MOTORS. The Reliance Electric & Engineering Co., Ivanhoe Road, Cleveland, Ohio, has issued Bulletin No. 109, as of September 1930, on Type AA induction motors with ball bearings for two- and three-phase a.c. circuits.

MOTORS, SMALL. The Westinghouse Electric & Manufacturing Co. has issued a 16-page publication, Circular 1883, covering the various types of small power motors and showing construction details.

NEMA STANDARDS. The National Electrical Manufacturers Association, 420 Lexington Ave., New York, N. Y., has issued "Nema Motor and Generator Standards," publication No. 30-2, as of October, 1930. The price is $1.50.

NICKEL STEEL. The International Nickel Co., Inc., 67 Wall St., New York, N. Y., has available a Buyer's Guide—Fall Issue, 1930—which is a directory of manufacturers, fabricators and distributors of nickel alloy steel products.

PUMPS. The Geo. D. Roper Corporation, Rockford, Ill., is distributing catalog No. 58 on rotary pumps. This 104-page book covers rotary pumps for hydraulic service, transfer of power, and for circulating coolants. Each type is illustrated and described and specifications are listed. An appendix of tables and engineering information on pumps is provided.

SCREW THREADS. The U. S. Department of Commerce, Bureau of Standards, has issued Commercial Standards CS25-30, entitled "American National Special Screw Threads." It is effective as of July 1, 1930. Copies can be secured from the U. S. Government Printing Office, Washington, for $0.15.

SPEED REDUCERS. The Foote Bros. Gear & Machine Co., 111 N. Canal St., Chicago, Ill., has issued catalog No. 102 on "IXL Titan" herringbone or helical speed reducers for heavy-duty drives. A general discussion of the design features is given. Dimension and rating tables are included as well as photographs of installations.

STEELS, S.A.E. SPECIFICATIONS. The International Nickel Co., Inc., 67 Wall St., New York, N. Y., has issued Bulletin No. 1-A describing in convenient form the S.A.E. system of specifications for chemical compositions and inspection standards for carbon and alloy steels. It has been brought up to date from an earlier bulletin.

TESTING MACHINES. The Tinius Olsen Testing Machine Co., 500 North Twelfth St., Philadelphia, Pa., has issued bulletin No. 1 illustrating and describing hardness testers and instruments.

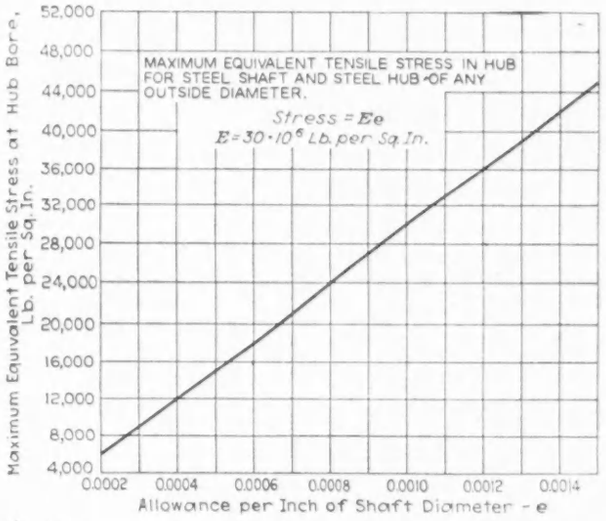
VARIABLE-SPEED TRANSMISSION. The Link-Belt Co., Philadelphia, Pa., has issued book No. 1274 describing the Link P.I.V. gear, a new positively-infinitely-variable speed transmission. Tables of dimensions and horsepower ratings are included.

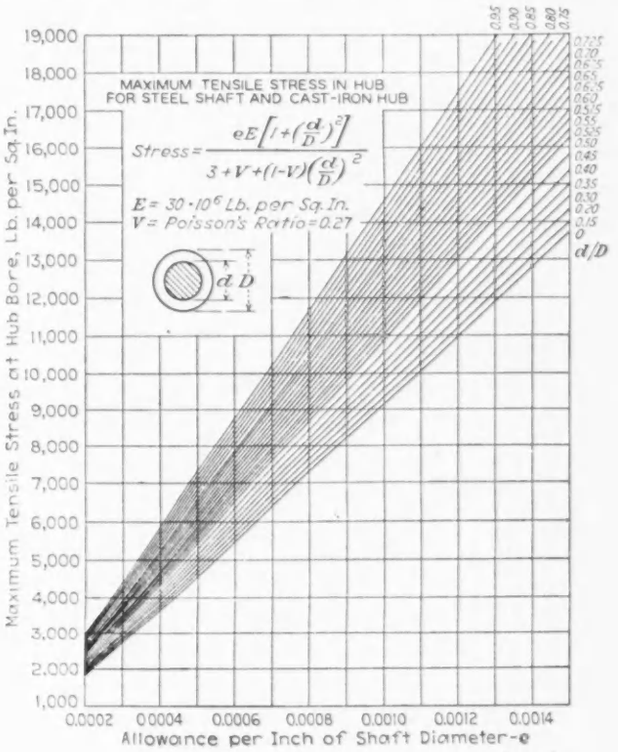
Torque Transmission in Press and Shrink Fits

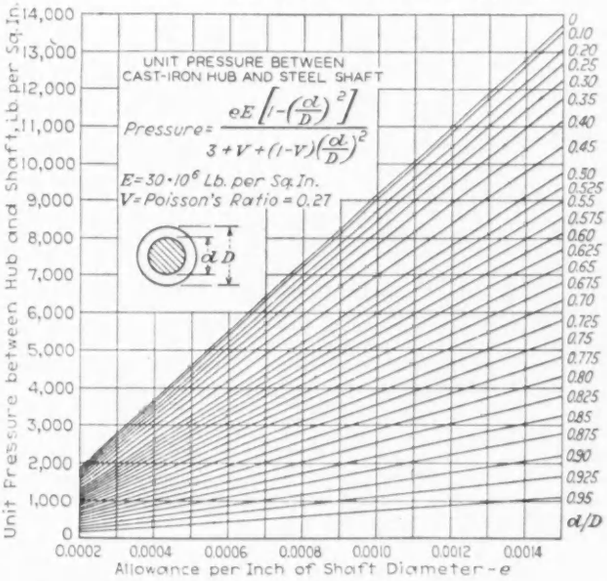
J. W. BAUGHER, Jr., in his paper, "Transmission of Torque by Means of Press and Shrink Fits," before the A.S.M.E. at the annual meeting, gave the following formulas for calculating the torque capable of being transmitted by a fit and the force in tons required to assemble the parts:

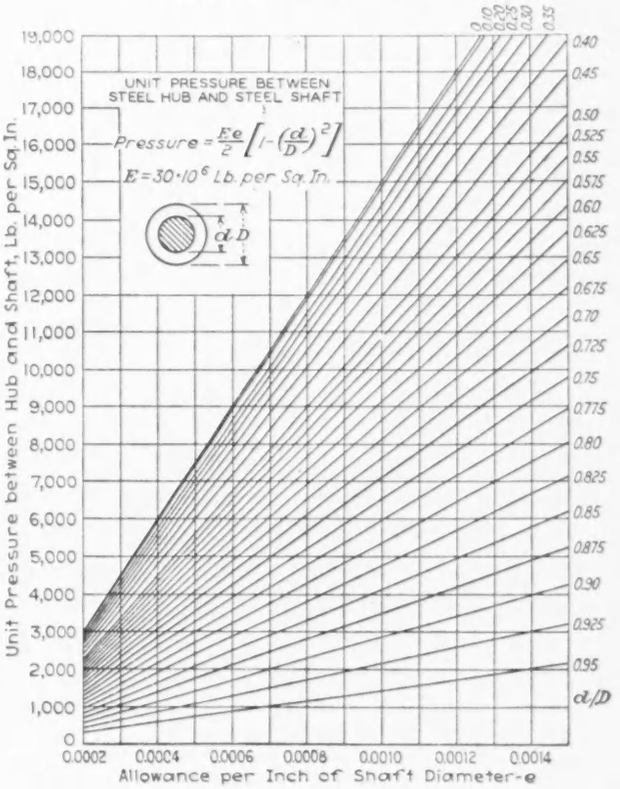
$$T = \frac{\pi f P L d^2}{2} \qquad F = \frac{\pi f_1 P L d}{2000}$$

where T is torque in lb. in, the coefficient of friction f is 0.10 for a press fit and 0.125 for a shrink fit, P is pressure obtained from the two lower charts on this page, L the actual length of the fit, d the shaft diameter, and f_1 the coefficient of friction, which may vary from 0.05 to 0.30 but averages 0.075. In case a key is used, the area πLd must be reduced by the area of the keyway. Coefficients were determined from a large number of fits.


MAXIMUM EQUIVALENT TENSILE STRESS IN HUB FOR STEEL SHAFT AND STEEL HUB OF ANY OUTSIDE DIAMETER.
Stress = Ee
E = 30 · 10⁶ Lb. per Sq. In.
Maximum Equivalent Tensile Stress at Hub Bore, Lb. per Sq. In.
Allowance per Inch of Shaft Diameter - e


MAXIMUM TENSILE STRESS IN HUB FOR STEEL SHAFT AND CAST-IRON HUB
Stress = eE[1+(d/D)²] / 3+V+(1-V)(d/D)²
E = 30 · 10⁶ Lb. per Sq. In.
V = Poisson's Ratio = 0.27
Maximum Tensile Stress at Hub Bore, Lb. per Sq. In.
Allowance per Inch of Shaft Diameter - e
d/D


UNIT PRESSURE BETWEEN CAST-IRON HUB AND STEEL SHAFT
Pressure = eE[1-(d/D)²] / 3+V+(1-V)(d/D)²
E = 30 · 10⁶ Lb. per Sq. In.
V = Poisson's Ratio = 0.27
Unit Pressure between Hub and Shaft, Lb. per Sq. In.
Allowance per Inch of Shaft Diameter - e
d/D


UNIT PRESSURE BETWEEN STEEL HUB AND STEEL SHAFT
Pressure = Ee/2 [1-(d/D)²]
E = 30 · 10⁶ Lb. per Sq. In.
Unit Pressure between Hub and Shaft, Lb. per Sq. In.
Allowance per Inch of Shaft Diameter - e
d/D

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Sizes and Tolerances for Metal Fits

SIZE	STANDARD HOLE MAX = BASIC	STUDS AND GROUND DIAMETERS NOT USED FOR STRAIGHT SHAFTS — RUNNING FIT	T	WRING FIT	T	FORCE FIT	T	RESULTING FITS: RUNNING FIT CLEARANCE	WRING FIT INTERFERENCE	FORCE FIT INTERFERENCE
1/4	.250 .2497	.249 .2493	3	.2503 .2500	3	.2503 .2506	3	.0004 .001	.0000 .0006	.0003 .0009
3/8	.375 .3747	.374 .3743	3	.3753 .3750	3	.3753 .3756	3	.0004 .001	.0000 .0006	.0003 .0009
1/2	.500 .4997	.499 .4993	3	.5003 .5000	3	.5003 .5006	3	.0004 .001	.0000 .0006	.0003 .0009
5/8	.625 .6247	.624 .6243	3	.6253 .6250	3	.6253 .6256	3	.0004 .001	.0000 .0006	.0003 .0009
3/4	.750 .7497	.749 .7493	3	.7503 .7500	3	.7503 .7506	3	.0004 .001	.0000 .0006	.0003 .0009
7/8	.875 .8747	.874 .8743	3	.8753 .8750	3	.8753 .8756	3	.0004 .001	.0000 .0006	.0003 .0009
1 —	1.000 .9997	.999 .9993	3	1.0003 1.0000	3	1.0003 1.0006	3	.0004 .001	.0000 .0006	.0003 .0009
1 1/8	1.125 1.1245	1.123 1.1235	5	1.1255 1.1250	5	1.1255 1.1260	5	.0010 .002	.0000 .001	.0005 .0015
1 1/4	1.250 1.2495	1.248 1.2485	5	1.2505 1.2500	5	1.2505 1.2510	5	.0010 .002	.0000 .001	.0005 .0015
1 3/8	1.375 1.3745	1.373 1.3735	5	1.3755 1.3750	5	1.3755 1.3760	5	.0010 .002	.0000 .001	.0005 .0015
1 1/2	1.500 1.4995	1.498 1.4985	5	1.5005 1.5000	5	1.5005 1.5010	5	.0010 .002	.0000 .001	.0005 .0015
1 5/8	1.625 1.6245	1.623 1.6235	5	1.6255 1.6250	5	1.6255 1.6260	5	.0010 .002	.0000 .001	.0005 .0015
1 3/4	1.750 1.7495	1.748 1.7485	5	1.7505 1.7500	5	1.7505 1.7510	5	.0010 .002	.0000 .001	.0005 .0015
1 7/8	1.875 1.8745	1.873 1.8735	5	1.8755 1.8750	5	1.8755 1.8760	5	.0010 .002	.0000 .001	.0005 .0015
2 —	2.000 1.9995	1.9975 1.998	5	2.0005 2.0000	5	2.0010 2.0015	5	.0015 .0025	.0000 .001	.0010 .0020
2 1/8	2.125 2.1245	2.1225 2.123	5	2.1255 2.1250	5	2.1260 2.1265	5	.0015 .0025	.0000 .001	.0010 .0020
2 1/4	2.250 2.2495	2.2475 2.248	5	2.2505 2.2500	5	2.2510 2.2515	5	.0015 .0025	.0000 .001	.0010 .0020
2 3/8	2.375 2.3745	2.3725 2.373	5	2.3755 2.3750	5	2.3760 2.3765	5	.0015 .0025	.0000 .001	.0010 .0020
2 1/2	2.500 2.4995	2.4975 2.498	5	2.5005 2.5000	5	2.5010 2.5015	5	.0015 .0025	.0000 .001	.0010 .0020
2 3/4	2.750 2.7495	2.7475 2.748	5	2.7505 2.7500	5	2.7510 2.7515	5	.0015 .0025	.0000 .001	.0010 .0020
3 —	3.000 2.9995	2.9975 2.998	5	3.0005 3.0000	5	3.0010 3.0015	5	.0015 .0025	.0000 .001	.0010 .0020
3 1/4	3.250 3.2493	3.2465 3.2472	7	3.2507 3.2500	7	3.2515 3.2522	7	.0021 .0035	.0000 .0014	.0015 .0029
3 1/2	3.500 3.4993	3.4965 3.4972	7	3.5007 3.5000	7	3.5015 3.5022	7	.0021 .0035	.0000 .0014	.0015 .0029
3 3/4	3.750 3.7493	3.7465 3.7472	7	3.7507 3.7500	7	3.7515 3.7522	7	.0021 .0035	.0000 .0014	.0015 .0029
4 —	4.000 3.9993	3.9965 3.9972	7	4.0007 4.0000	7	4.0015 4.0022	7	.0021 .0035	.0000 .0014	.0015 .0029
4 1/4	4.250 4.2493	4.2465 4.2472	7	4.2507 4.2500	7	4.2515 4.2522	7	.0021 .0035	.0000 .0014	.0015 .0029
4 1/2	4.500 4.4993	4.4965 4.4972	7	4.5007 4.5000	7	4.5015 4.5022	7	.0021 .0035	.0000 .0014	.0015 .0029
4 3/4	4.750 4.7493	4.7465 4.7472	7	4.7507 4.7500	7	4.7515 4.7522	7	.0021 .0035	.0000 .0014	.0015 .0029
5 —	5.000 4.999	4.9955 4.9965	10	5.0010 5.0000	10	5.0020 5.0030	10	.0025 .0045	.0000 .002	.0020 .0040
5 1/4	5.250 5.249	5.2455 5.2465	10	5.2510 5.2500	10	5.2520 5.2530	10	.0025 .0045	.0000 .002	.0020 .0040
5 1/2	5.500 5.499	5.4955 5.4965	10	5.5010 5.5000	10	5.5020 5.5030	10	.0025 .0045	.0000 .002	.0020 .0040
5 3/4	5.750 5.749	5.7455 5.7465	10	5.7510 5.7500	10	5.7520 5.7530	10	.0025 .0045	.0000 .002	.0020 .0040
6 —	6.000 5.999	5.9955 5.9965	10	6.0010 6.0000	10	6.0020 6.0030	10	.0025 .0045	.0000 .002	.0020 .0040

SIZE	SHAFT DIAMETERS	HOLE SIZES FOR GROUND SHAFTS ONLY — NOT USED FOR STUDS OR COMM COLD DRAWN BARS — RUNNING FIT HOLES STANDARD	T	WRING FIT	T	FORCE FIT HOLES EXCEPTIONAL TO STANDARD	T	RESULTING FITS: RUNNING FIT CLEARANCE	WRING FIT INTERFERENCE	FORCE FIT INTERFERENCE
1/4	.2493 .249	.250 .2497	3	.2490 .2487	3	.2484 .2487	3	.0004 .001	.0000 .0006	.0003 .0009
3/8	.3743 .374	.375 .3747	3	.3740 .3737	3	.3734 .3737	3	.0004 .001	.0000 .0006	.0003 .0009
1/2	.4993 .499	.500 .4997	3	.4990 .4987	3	.4984 .4987	3	.0004 .001	.0000 .0006	.0003 .0009
5/8	.6243 .624	.625 .6247	3	.6240 .6237	3	.6234 .6237	3	.0004 .001	.0000 .0006	.0003 .0009
3/4	.7493 .749	.750 .7497	3	.7490 .7487	3	.7484 .7487	3	.0004 .001	.0000 .0006	.0003 .0009
7/8	.8743 .874	.875 .8747	3	.8740 .8737	3	.8734 .8737	3	.0004 .001	.0000 .0006	.0003 .0009
1 —	.9993 .999	1.000 .9997	3	.9990 .9987	3	.9984 .9987	3	.0004 .001	.0000 .0006	.0003 .0009
1 1/8	1.1235 1.123	1.125 - 1.1245	5	1.1230 - 1.1225	5	1.1220 - 1.1225	5	.0010 .002	.0000 .001	.0005 .0015
1 1/4	1.2485 1.248	1.250 - 1.2495	5	1.2480 - 1.2475	5	1.2470 - 1.2475	5	.0010 .002	.0000 .001	.0005 .0015
1 3/8	1.3735 1.373	1.375 - 1.3745	5	1.3730 - 1.3725	5	1.3720 - 1.3725	5	.0010 .002	.0000 .001	.0005 .0015
1 1/2	1.4985 1.498	1.500 - 1.4995	5	1.4980 - 1.4975	5	1.4970 - 1.4975	5	.0010 .002	.0000 .001	.0005 .0015
1 5/8	1.6235 1.623	1.625 - 1.6245	5	1.6230 - 1.6225	5	1.6220 - 1.6225	5	.0010 .002	.0000 .001	.0005 .0015
1 3/4	1.7485 1.748	1.750 - 1.7495	5	1.7480 - 1.7475	5	1.7470 - 1.7475	5	.0010 .002	.0000 .001	.0005 .0015
1 7/8	1.8735 1.873	1.875 - 1.8745	5	1.8730 - 1.8725	5	1.8720 - 1.8725	5	.0010 .002	.0000 .001	.0005 .0015
2 —	1.998 1.9975	2.000 - 1.9995	5	1.9975 - 1.9970	5	1.9960 - 1.9965	5	.0015 .0025	.0000 .001	.0010 .0020
2 1/8	2.123 2.1225	2.125 - 2.1245	5	2.1225 - 2.1220	5	2.1210 - 2.1215	5	.0015 .0025	.0000 .001	.0010 .0020
2 1/4	2.248 2.2475	2.250 - 2.2495	5	2.2475 - 2.2470	5	2.2460 - 2.2465	5	.0015 .0025	.0000 .001	.0010 .0020
2 3/8	2.373 2.3725	2.375 - 2.3745	5	2.3725 - 2.3720	5	2.3710 - 2.3715	5	.0015 .0025	.0000 .001	.0010 .0020
2 1/2	2.498 2.4975	2.500 - 2.4995	5	2.4975 - 2.4970	5	2.4960 - 2.4965	5	.0015 .0025	.0000 .001	.0010 .0020
2 3/4	2.748 2.7475	2.750 - 2.7495	5	2.7475 - 2.7470	5	2.7460 - 2.7465	5	.0015 .0025	.0000 .001	.0010 .0020
3 —	2.998 2.9975	3.000 - 2.9995	5	2.9975 - 2.9970	5	2.9960 - 2.9965	5	.0015 .0025	.0000 .001	.0010 .0020

SIZE	SHAFT DIAMETERS MAX = BASIC	TOLERANCE GRADE	HOLE SIZES FOR COMMERCIAL COLD DRAWN BARS — NOT USED ON STUDS OR GROUND SHAFTS — RUNNING FITS	T	WRING FIT	T	FORCE FIT	T	RESULTING FITS: RUNNING FIT INTERFERENCE	RUNNING FIT CLEARANCE	WRING FIT INTERFERENCE	FORCE FIT INTERFERENCE
1/4	.250 - .248	2	.250 - .2497	3	.248 - .2477	3	.2478 - .2475	3	.0003	.002	.0000 - .0028	.0002 - .0025
3/8	.375 - .372	3	.375 - .3747	3	.372 - .3717	3	.3718 - .3715	3	.0003	.003	.0000 - .0033	.0002 - .0035
1/2	.500 - .497	3	.500 - .4997	3	.497 - .4967	3	.4968 - .4965	3	.0003	.003	.0000 - .0033	.0002 - .0035
5/8	.625 - .622	3	.625 - .6247	3	.622 - .6217	3	.6218 - .6215	3	.0003	.003	.0000 - .0033	.0002 - .0035
3/4	.750 - .747	3	.750 - .7497	3	.747 - .7467	3	.7468 - .7465	3	.0003	.003	.0000 - .0033	.0002 - .0035
7/8	.875 - .872	3	.875 - .8747	3	.872 - .8717	3	.8718 - .8715	3	.0003	.003	.0000 - .0033	.0002 - .0035
1 —	1.000 - .997	3	1.000 - .9997	3	.997 - .9967	3	.9968 - .9965	3	.0003	.003	.0000 - .0033	.0002 - .0035
1-1/8	1.125 - 1.121	4	1.125 - 1.1245	5	1.121 - 1.1205	5	1.1205 - 1.120	5	.0005	.004	.0000 - .0045	.0005 - .005
1-1/4	1.250 - 1.246	4	1.250 - 1.2495	5	1.246 - 1.2455	5	1.2455 - 1.245	5	.0005	.004	.0000 - .0045	.0005 - .005
1-3/8	1.375 - 1.371	4	1.375 - 1.3745	5	1.371 - 1.3705	5	1.3705 - 1.370	5	.0005	.004	.0000 - .0045	.0005 - .005
1-1/2	1.500 - 1.496	4	1.500 - 1.4995	5	1.496 - 1.4955	5	1.4955 - 1.495	5	.0005	.004	.0000 - .0045	.0005 - .005
1-5/8	1.625 - 1.621	4	1.625 - 1.6245	5	1.621 - 1.6205	5	1.6215 - 1.621	5	.0005	.004	.0000 - .0045	.0005 - .005
1-3/4	1.750 - 1.746	4	1.750 - 1.7495	5	1.746 - 1.7455	5	1.7455 - 1.745	5	.0005	.004	.0000 - .0045	.0005 - .005
1-7/8	1.875 - 1.871	4	1.875 - 1.8745	5	1.871 - 1.8705	5	1.8705 - 1.870	5	.0005	.004	.0000 - .0045	.0005 - .005
2 —	2.000 - 1.996	4	2.000 - 1.9995	5	1.996 - 1.9955	5	1.9955 - 1.9945	5	.0005	.004	.0000 - .0045	.001 - .0055
2-1/8	2.125 - 2.121	4	2.125 - 2.1245	5	2.121 - 2.1205	5	2.120 - 2.1195	5	.0005	.004	.0000 - .0045	.001 - .0055
2-1/4	2.250 - 2.246	4	2.250 - 2.2495	5	2.246 - 2.2455	5	2.245 - 2.2445	5	.0005	.004	.0000 - .0045	.001 - .0055
2-3/8	2.375 - 2.371	4	2.375 - 2.3745	5	2.371 - 2.3705	5	2.370 - 2.3695	5	.0005	.004	.0000 - .0045	.001 - .0055
2-1/2	2.500 - 2.496	4	2.500 - 2.4995	5	2.496 - 2.4955	5	2.495 - 2.4945	5	.0005	.004	.0000 - .0045	.001 - .0055
2-3/4	2.750 - 2.745	5	2.750 - 2.7495	5	2.745 - 2.7445	5	2.7435 - 2.743	5	.0005	.005	.0000 - .0055	.0015 - .007
3 —	3.000 - 2.995	5	3.000 - 2.9995	5	2.995 - 2.9945	5	2.9935 - 2.993	5	.0005	.005	.0000 - .0055	.0015 - .007

IN HIS paper, "Sizes and Tolerances for Metal Fits," presented before the A.S.M.E. at the annual meeting, C. R. Reiman of the American Type Founders Company compared metal fits conforming to various standards, and submitted the standard used by his company, based on an analysis of existing standards and adapted to the needs of his company. In all cases, standard holes are basic size to under, no positive tolerances being allowed. The upper table refers to studs and prices with length of fit short in proportion to their diameters, giving maximum and minimum dimensions for both members. The hole size is common to all three kinds of fits, while the stud size changes in agreement with the kind of fit. The next table is for ground straight shafts, the maximum of the hole only being basic for running fits. In this group, the shaft size is common, the hole size being changed for the wring and force fits. The final table is for commercial cold-drawn or rolled bars where shaft diameter is uniform to standard commercial tolerances and fits are of less importance than for ground shafts. In all three tables, *T*, the tolerance, is given in tenths of thousandths of an inch.

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